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# *Opuscula Philolichenum*

*small works in the field of lichenology*

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## MISSION

*Opuscula Philolichenum* is intended to serve as a venue for the publication of small works in the field of lichenology (including lichenicolous fungi and non-lichenized fungi traditionally treated with lichens). The central goal of the journal is to provide timely publication, in a professional format, free of charge to authors and readers. While the journal focuses on topics relating to the lichen biota of North America this is by no means exclusive and manuscripts on other topics will be considered as the table of contents of the present issue clearly illustrates.

Authors wishing to submit a manuscript for publication in *Opuscula Philolichenum* should contact the editor prior to submission to confirm that the paper conforms to the mission of the journal (outlined above). Manuscript submissions should be left unformatted and authors should consult a recent issue of *Opuscula Philolichenum* for style. All submissions are subjected to review by at least two peer reviewers and, following acceptance are formatted by the editor.

## NOTICE FROM THE EDITOR

When this journal began publication ten years ago it was among the first serials to take advantage of the internet when publishing new botanical nomenclatural acts. The journal was conceived as a primarily electronic one, available on-line free of charge (at <http://sweetgum.nybg.org/philolichenum/>), with a limited print run to satisfy the requirements for effective publication established under the *International Code for Botanical Nomenclature*. Since that time we have continued to publish the journal in this manner, printing one or two issues a year, with each issue consisting of between one and two hundred pages.

In 2004 we could not have foreseen the revolutionary changes that took place at the 18<sup>th</sup> International Botanical Congress in Melbourne. There the Nomenclature Section voted to allow electronic only publication of new nomenclatural acts beginning 1 January 2012. In response to this change *Opuscula Philolichenum* no longer produces hardcopy. Although a single printed copy will continue to be deposited in the library of The New York Botanical Garden.

Beginning with volume number 12 of *Opuscula Philolichenum*, manuscripts are published electronically on-line in PDF/A format immediately following the approval of the authors in the post-review proof stage. The PDF issued online is considered to be the final version (= version of record) and the date on which the PDF is posted is considered to be the date of effective publication. In order to aid future workers the date of effective publication for each manuscript is provided in the table of contents. When a new manuscript is published online a record is also simultaneously transmitted to the organizers of *Recent Literature on Lichens* for inclusion in that database.

## THANKS TO OUR REVIEWERS

As with all previous issue of *Opuscula Philolichenum* the backbone of a journal is its cohort of reviewers. Therefore we take this opportunity to thank those researchers who have generously agreed to review manuscripts submitted for consideration in the journal in 2014: Violeta Atienza – Valencia, Spain; Curtis Björk – Clearwater, Canada; Irwin Brodo – Ottawa, Canada; Stephen Clayden – St. John, Canada; Damien Ertz – Meise, Belgium – Theodore Esslinger – Fargo, U.S.A.; Javier Etayo – Navarro, Spain; Alan Fryday – East Lansing, U.S.A.; Richard C. Harris – Bronx, U.S.A.; Kerry Knudsen – Riverside, U.S.A.; Martin Kukwa – Gdansk, Poland; Robert Lücking – Chicago, U.S.A.; Patrick McCarthy – Canberra, Australia; Bruce McCune, Corvallis, U.S.A.; Thomas H. Nash – Madison, U.S.A.; Caleb Morse – Lawrence, U.S.A.; Alan Orange – Cardiff, Wales; Sergio Perez-Ortega – Madrid, Spain; Maria Prieto – Madrid, Spain; Larry St. Clair – Provo, U.S.A.; Ulf Schiefelbein – Rostock, Germany; Matthias Schultz – Hamburg, Germany; Harrie Sipman – Berlin, Germany; Taylor Quedensley – Valdosta, U.S.A.; Shirley Tucker – Santa Barbara, U.S.A.; Bernard de Vries – Saskatoon, Canada.



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## *Phaeospora catolechia*, a lichenicolous fungus on *Catolechia wahlenbergii*, new to North America

MIKHAIL P. ZHURBENKO<sup>1</sup>

ABSTRACT. – *Phaeospora catolechia* is reported new to North America from Canada. A revised description of the species is provided as are color illustrations.

KEYWORD. – biogeography.

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### INTRODUCTION

While working in the lichen herbarium of the Finnish Museum of Natural History at the University of Helsinki (H), I found several specimens of the lichenicolous fungus *Phaeospora catolechia* Zopf, one of which represents the first record from North America. So far, the species has been reported only from central and northern Europe, namely from the Slovak Republic, Austria, Germany, Sweden and Norway (Hafellner 1999, Kocourková 2000, Santesson et al. 2004, Wirth 1990, Zopf 1898). In addition to formally providing the North American report here, I provide the first revised description since Zopf (1898), as well as color illustrations to facilitate identification.

### METHODS

Material used in this study was examined with Zeiss microscopes Stemi 2000–CS and Axio Imager A1 equipped with Nomarski differential interference contrast optics. Microscopical examination was done in water, 10% KOH (K) or Lugol's iodine, directly (I) or after a KOH pre-treatment (K/I). The length, breadth, and length/breadth ratio (l/b) of asci and ascospores are given as: (min–){X –SD}–{X +SD}(–max), where min and max are the extreme values, X the arithmetic mean, and SD the corresponding standard deviation.

### THE NEW REPORT AND REVISED DESCRIPTION

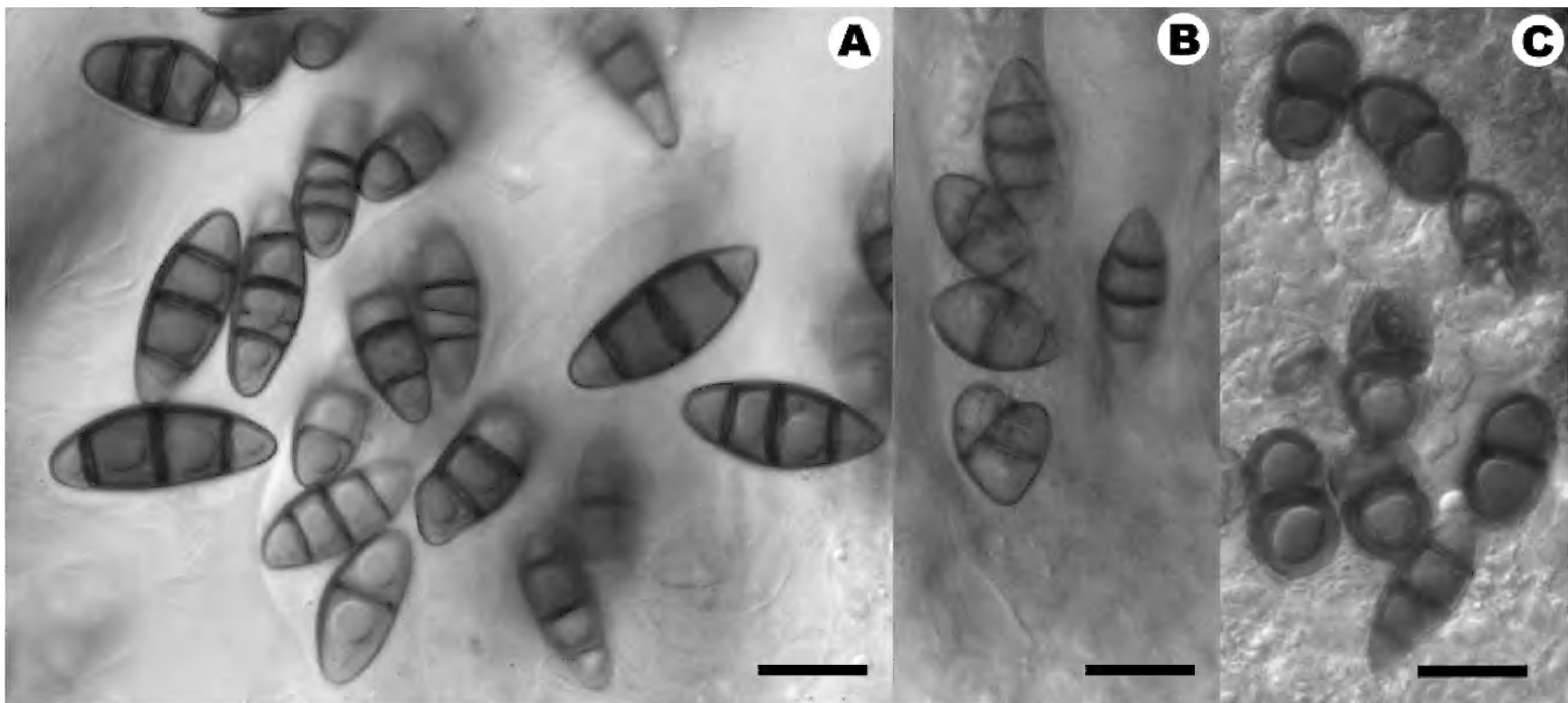
#### *Phaeospora catolechia* Zopf

#### FIGURE 1

DESCRIPTION. – *Vegetative hyphae* brown, 1.5–2.5 µm diam. *Ascomata* perithecioid, subglobose, black, glossy, 125–250(–300) µm diam., dispersed to aggregated and adjacent, semi-immersed to sessile; wall brown throughout, sometimes with orange tinge, K+ olivaceous-brown, in surface view of *textura angularis*, of cells (2.5–)4–6(–10) µm across. *Periphyses* 1–1.5 µm diam., apically not or slightly swollen. *Periphysoids* septate, occasionally branched, 15–25 × 1–2.5 µm, often tapering slightly toward the apex. *Hymenial gel* I+ red, K/I+ blue. *Asci* bitunicate, elongate ellipsoid, clavate to subcylindrical, distinct ocular chamber not observed, (55–)60–68(–70) × (14–)15–17(–20) µm (n = 27, in water, I or K/I), wall I and K/I–,

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**Figure 1**, ascospores of *Phaeospora catolechiaae*. A, typical ascospores in K (*Mayrhofer s.n.*, H). B, atypical ascospores in K/I (*Buch s.n.*, H). C, atypical ascospores in water (*Ahti 44341a*, H). Scale bars = 10 µm.

8-spored. *Ascospores* hyaline at first then medium brown, K+ olivaceous-brown, apical cells sometimes slightly paler than the median ones, variable in shape and size (Fig. 1), mainly narrowly ellipsoid or narrowly obovate (with narrower lower cell), sometimes ellipsoid to broadly ellipsoid, occasionally with an apiculus, (1–)3(–4)-trans-septate, very rarely with oblique septa, not or slightly constricted at the septa, (10.0–)13.6–19.0(–24.5) × (4.8–)5.6–7.6(–10.0) µm, l/b = (1.1–)1.9–3.1(–4.4) (n = 116, in water, I or K/I), often with one large guttule in each cell, wall 0.5–1 µm thick, smooth, non-halonate, irregularly biseriate in an ascus. Pathogenicity not observed.

*Specimens examined (all on squamules of Catolechia wahlenbergii* (Ach.) Körber, *mostly along their margins*). – **CANADA. BRITISH COLUMBIA:** Haida Gwaii (Queen Charlotte Islands), Moresby Island, “Laing Point Mountain”, SE of road into Peel Inlet, ca. 1 mile E of Laing Point, 52°59'N, 132°04'W, elev. ca. 650 m, forested slope and subalpine bluffs near summit, on exposed rock outcrop, 2.vii.1967, *I.M. Brodo 10798a* (H, LE 261053). **NORWAY. SØR-TRØNDELAG:** Oppdal, near Kongsvoll, by Sprenbäcken Brook, 62°19.1'N, 9°37.2'E, elev. 900 m, 7.viii.1909, *H. Buch s.n.* (H). **OPPLAND:** Vang, S of Beito, S-SE slope of Raudhorn Mountain, elev. 1060 m, lower oroarctic zone, in rock crevices on cliff, 6.viii.1985, *T. Ahti 44341a* (H). **AUSTRIA. STEIERMARK:** Schlaminger Tauern, Kleinsölktal, Grosslochrinnengrat über der Breitlahnalm, elev. 2150 m, 8.vii.1985, *M. Mayrhofer & H. Mayrhofer s.n.* (H).

#### ACKNOWLEDGEMENTS

Einar Timdal, Teuvo Ahti and Irwin Brodo are thanked for elaboration of the label information. The reviewers also are thanked for the reviews of the manuscript.

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## Notes on the California Lichen Flora 6: New Records

KERRY KNUDSEN<sup>1</sup> AND JANA KOCOURKOVÁ<sup>2</sup>

**ABSTRACT.** – *Lecidea confluentula* is reported new for North America and California. *Calogaya pusilla* and *Cercidospora cecidiiformans* (lichenicolous on *Rhizocarpon riparium*) are reported new for California.

**KEYWORD.** – Biodiversity, calciphiles, Channel Islands, lichenicolous fungi, San Bernardino Mountains.

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### INTRODUCTION

Earlier installments of this series were published in the *Bulletin of the California Lichen Society*. This and a similar series published in *Crossosoma* reported new records of lichens and lichenicolous fungi from California and were published once or twice a year. We have decided to consolidate our future California reports in *Opuscula Philolichenum*, where they are peer reviewed, indexed for Scopus, and readily available for free download.

The first author began publishing California reports at the request of Shirley Tucker, the editor of the checklist of lichens and lichenicolous fungi of California (Tucker 2014). In the regular course of work, unexpected new discoveries are often made. These records frequently do not fit into any taxonomic or floristic papers being prepared for publication. Unpublished, they can often be forgotten, the specimen hidden in the darkness of a herbarium cabinet. Here we report three species (two crustose lichens and one lichenicolous fungus) for the first time from California. One of these reports is also the first for North America.

Overall, California is still unexplored for lichens and lichenicolous fungi. Currently more than 1,869 taxa are reported from the state (Hutten et al. 2013; Knudsen et al. 2013a, b & c; Tucker 2014). The recent revision of the California checklist (Tucker 2014) included an additional 295 taxa that had been reported new for California since 2006, and this increase did not include many new records from Yosemite National Park (Hutten et al. 2013).

### METHODS

Specimens were examined from LD, OSC, UCR, and the Herbarium Mycologicum of Jana Kocourková and Kerry Knudsen (abbreviated herein “hb. Kocourková and Knudsen”). Hand-made sections were studied in water and 10% KOH [K]. Amyloid reactions were tested in Lugol’s iodine 1% with and without pre-treatment with KOH 5% [K/I]. Ascospore measurements were made in water with accuracy of 0.5 µm. Secondary metabolites were studied using standardized Thin Layer Chromatography (Culberson & Ammann 1979, Culberson & Johnson 1982, Orange et al. 2001, 2010). Note that here we recognize the genera *Calogaya* Arup, Frödén & Søchting and *Polycauliona* Hue that were recently segregated from *Caloplaca* Th. Fr. by Arup et al. (2013) on the basis of molecular phylogenetic analyses.

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## NEW REPORTS

1. *Calogaya pusilla* (A. Massal.) Arup, Frödén & Söchting, Nordic J. Bot. 31: 39. 2013.  
 ≡ *Caloplaca pusilla* (A. Massal.) Zahlbr. Cat. Lich. Univ. 4: 353 1926.  
 ≡ *Physcia pusilla* A. Massal., Atti R. Ist. Ven. Sc. Lett. Arti, ser. 2, 3(appendix 3): 59, fig. 8.1852.  
**TYPE: ITALY:** Veneto, Vigint ad saxa jurassica provincia Veronensis in locus apertis (VER[n.v.], holotype).

*Calogaya pusilla* is common in Europe and was earlier reported from North America (Iowa, Minnesota, North Dakota, and South Dakota) as *Caloplaca pusilla* (Gaya 2009, Wirth et al. 2013) and as one of three morphotypes of *C. saxicola* (Hoffm.) Nordin (Wetmore & Kärnefelt 1998). For a description and illustrations of the taxon see Gaya (2009). Specimens vary but are usually evenly pruinose, tightly attached to the substrate, orbicular to confluent, and have dense aggregations of apothecia toward the center of the thallus. The outer lobes can be broad and flattened or elongate and terete. It usually grows on vertical surfaces on calcareous rocks and often on walls with mortar and is considered a calciphile.

The specimen reported here is from Santa Rosa Island and was found growing on Monterey shale, a common calcareous substrate on the island. It has broad flattened lobes and is ochre yellow with a fine white pruina. Of the three other effigurate species of Teloschistaceae that are known from the Channel Islands in southern California (Knudsen & Kocourková 2012), *Calogaya pusilla* can only be confused with the common *Polycauliona impolita* (Arup) Arup, Frödén & Söchting, which differs in having a distinctly yellow pruina confined to its broad lobes. On the Channel Islands, *Caloplaca saxicola* is epruinose, distinctly more orange in color, with apothecia more frequent near the lobe edges. *Polycauliona ignea* (Arup) Arup, Frödén & Söchting is epruinose and definitely darker red in color than *C. pusilla*. *Polycauliona brattiae* (W.A. Weber) Arup, Frödén & Söchting is often abundant with *P. impolita* on volcanic rock on the islands. It is epruinose and redder in color, with narrower convex lobes than *Calogaya pusilla*. A beautiful salmon colored form of *C. pusilla*, that is common in Europe, was illustrated by Wirth et al. (2013).

*Specimen examined.* – **U.S.A. CALIFORNIA.** SANTA BARBARA CO.: Channel Islands National Park. Santa Rosa Island, Quemada Canyon, 33°57'46"N 120°0'46"W, 26 m, on Monterey shale, 19.vii. 2007, K. Knudsen 6878 & J. Kocourková (UCR, hb. Vondrák; collection determined by J. Vondrák).

2. *Cercidospora cecidiiformans* Hafellner & Grube, Herzogia 9: 752. 1992. **TYPE: NORWAY.** HORDALAND: Odda, Valldalen N von Rødal, W-Abhänge des Berges Middalsrusta gegen den See Vivassvatnet; auf Blöcken am Hang, ca 950 m, auf *Rhizocarpon geographicum* zusammen mit *Muellerella pygmaea*, 18.viii.1984, J. Hafellner 11671 (GZU[n.v.], holotype).

*Cercidospora cecidiiformans* was originally described from Norway as growing on species of *Rhizocarpon* subg. *Rhizocarpon* (Hafellner 1993). Hafellner et al. (2002) subsequently reported *C. cecidiiformans* as new for North America from Greenland. The species was later reported from Sweden (Ihlen & Wedin 2005) and for continental North America from Alaska on *R. geographicum* (L.) DC. (Spribille et al. 2010). It forms pillow-like galls on the thalli of the host, each containing up to 30 hyaline perithecia. The ascospores are hyaline, 1-septate, 13–15.5–19 × 5–6–8 µm in size, with thin but distinct halo.

The species is here reported new for California as it is not included in any recent checklists of lichens and lichenicolous fungi from the state (Hutten et al. 2013, Kocourková et al. 2012, Tucker 2014). It was collected on *Rhizocarpon riparium* Räsänen on a large granite outcrop in the San Bernardino Mountains at 2439 meters (8000 feet) with other montane lichen species that are rare in southern California including *Carbonea vorticosa* (Flörke) Hertel (UCR Herbarium 2014).

*Specimen examined.* – **U.S.A. CALIFORNIA.** SAN BERNARDINO CO.: San Bernardino National Forest, San Bernardino Mountains, large granite outcrop within sight of Highway 38 and Rainbow Lane, 34°10'22.6"N 116°43'5.6"W, 2439 m, 3.ix.2013, on *Rhizocarpon riparium* on granite, J. Kocourková 8374. & K. Knudsen (hb. Kocourková and Knudsen).

3. *Lecidea confluentula* Müll. Arg., Flora 55: 536. 1872. **TYPE: FRANCE.** DEPT. HAUTE-SAVOIE: Mount Salève, on rock (saxis siderolithicus), 22.ix.1872, *J. Müller-Argoviensis s.n.* (G[n.v.], holotype).

*Lecidea confluentula* is a member of *Lecidea* s. str., occurring in Europe and Asia on siliceous rocks (Aptroot et al. 2009; Arup 2004; Hertel 1995, 2006; Hertel & Andreev 2003). For descriptions the reader can refer to the following publications (Aptroot et al. 2009, Arup 2004, Müller 1872). It is a semi-cryptic species within the *L. fuscoatra* group, with a thin, dispersed or endolithic thallus, the main morphological character separating it from *L. fuscoatra* which has a well-developed thallus. Arup (2004) demonstrated through molecular phylogenetic analysis using ITS that *L. confluentula* was distinct from *L. fuscoatra*. The black apothecia of *L. confluentula* are smooth or rugulose, sometimes with a thin layer of pruina, 0.4–1.0(–1.5) mm in diameter, with either a well-developed rim with a flat disc or else the disc becomes convex excluding the margin. The exciple is 45–75 µm wide. The hymenium is 50–100 µm tall. The epihymenium is brownish-black to blue-green. Ascospores are broadly ellipsoid, (9–)10–13(–15) × (4–)5–7(–7.5) µm. The hypothecium is dark brown. *Lecidea confluentula* produces the gyrophoric acid syndrome (Arup 2004). The thallus and exciple are KC+ pink (though the reaction is often faint and transient) and the chemistry is best analyzed with Thin Layer Chromatography.

*Lecidea confluentula* was collected on a wet rock along the Tuolumne River in Tuolumne County, California, in the foothills of the Sierra Nevada Mountains, at 356 meters (1170 feet). The specimen is completely endolithic and was compared with specimens from LD collected in Skåne and Halland in Sweden by Ulf Arup. *Lecidea confluentula* is here reported new for North America and California (Esslinger 2012, Hutten et al. 2013, Tucker 2014). Its association with a river in California suggests that it could be rare, possibly restricted to humid sites with perennial water at lower to middle elevations. As in Fennoscandia, typical populations of *L. fuscoatra* with well-developed brown thalli are sympatric with *L. confluentula* in central California in the Sierra Nevada Mountains (Hutten et al. 2013, Knudsen 2012).

A similar endolithic species *Lecidea cinerata* Zahlbr., produces lecanoric acid and thus also has a KC+ reaction in the exciple. It is distinguished from *L. confluentula* by its hyaline or weakly inspersed hypothecium and longer ascospores that average 13–16 µm in length (Hertel & Printzen 2004). *Lecidea cinerata* is endemic to middle to high elevations in the more arid mountains of southern California (Hertel & Printzen 2004, Tucker 2014, UCR Herbarium 2014). Both *L. confluentula* and *L. cinerata*, as well as the common *L. laboriosa* Müll. Arg. and several other usually endolithic *Lecidea* species in California, have apothecia with high morphological variability and cannot be readily separated using the apothecial gestalt. They must be distinguished by ascospores, inspersation and color of the hypothecium (from hyaline to brown or black), sometimes pycnidial type or conidia, and which secondary metabolites are produced that can be detected with spot tests or Thin Layer Chromatography. In California *L. confluentula* could be naturally rare but could also be easily overlooked in the field or either misidentified or unidentified in herbaria.

*Specimen examined.* – **U.S.A. CALIFORNIA.** TUOLUMNE CO.: Tuolumne River, 37°51'48.3"N 120°07'0.8"W, 356 m, on fully exposed mesic rock, 4.viii.2011, *M. Hutten 15535* (OSC).

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## Studies in Lichens and Lichenicolous Fungi No. 17 – Notes on Lichens from the Coastal Plain of Southeastern North America

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**ABSTRACT.** – The first confirmed North American report of *Acrocordia gemmata* is presented. The first fertile collections of *Heiomasia seaveyorum* are documented and illustrated. The recent North American report of *Lecanora barkmaniana* is shown to be based on a misidentification of *L. floridula*. The following species are reported for the first time from North America: *Ochrolechia isidiata* (Georgia, U.S.A.) and *Roselliniopsis tropica* (Delaware, Maryland and North Carolina, U.S.A.; lichenicolous on *Ochrolechia africana*). The distinguishing features of *Pertusaria obruta* and *P. sinusmexicani* are discussed, the species are illustrated, and maps of the revised distributions are presented.

**KEYWORD.** – new records, biogeography, subtropical, sorediate crust, pond cypress.

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### INTRODUCTION

In 2012, we received funding from the U.S. National Science Foundation to initiate an inventory of the lichen biota of the Mid-Atlantic Coastal Plain (MACP) of eastern North America. The MACP comprises a large expanse of low-lying ecosystems adjacent to the Atlantic Ocean between southern New Jersey and northern Florida (USEPA 2002). This region is a subdivision of the much larger Coastal Plain of eastern North America that extends along the Atlantic coastline from Nova Scotia to Florida, and the Gulf of Mexico coastline from Florida west to southeastern Texas (Omernik 1995). With few exceptions the lichen biota of the MACP has received little attention previously (Hodkinson & Case 2008, Lendemer 2013, Lendemer & Knapp 2007, Lendemer & Yahr 2004, Perlmutter 2007) and thus it is not surprising that our inventory efforts have yielded numerous new and interesting discoveries (Lendemer 2013, Lendemer & Harris in press). In addition to discoveries resulting from our fieldwork we have uncovered a significant number of new and interesting taxa through the revision of herbarium specimens from the Coastal Plain that were recently sent to us for study. Here we present several notes on lichens occurring in the Coastal Plain of southeastern North America.

### MATERIALS AND METHODS

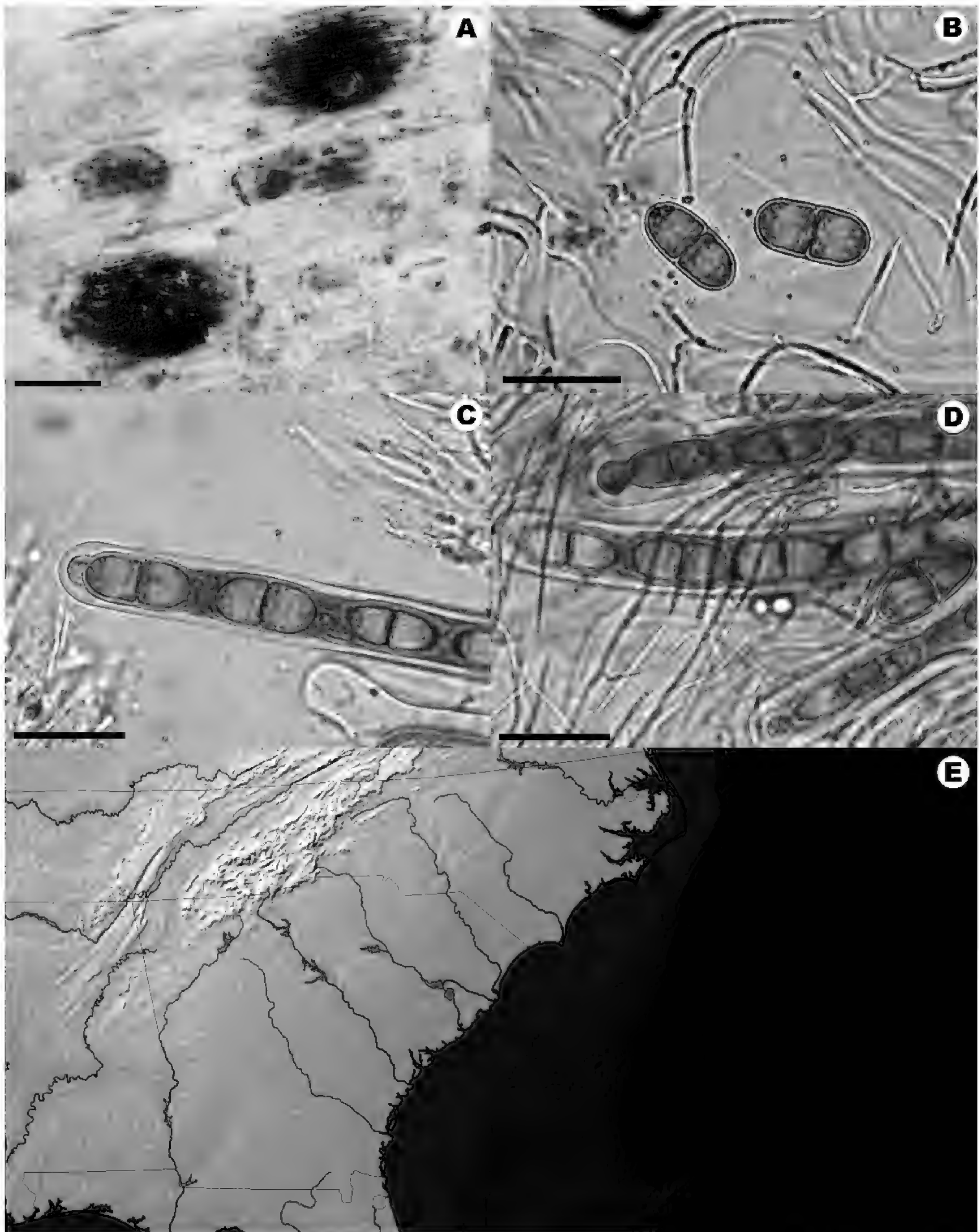
This study is based largely on specimens collected by the authors as part of their inventory of the MACP. These are deposited in the Steere Herbarium of The New York Botanical Garden (NY). Additional specimens from NY were used in this study, as well one specimen loaned from FLAS. Specimens sent to us for identification by Malcolm Hodges and Roger Rosentreter have also been deposited at NY.

The morphology of specimens was examined following the techniques of microscopy outlined by Lendemer (2011b). The chemistry was studied with standard spot test reagents following Brodo et al. (2001) and with Thin Layer Chromatography using Solvents A or C and the so called “Peanut Butter Jar” method outlined by Lendemer (2011b). Micrographs were captured following the methods outlined by Lendemer (2011b).

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**Figure 1**, morphology and North American distribution of *Acrocordia gemmata* (all micrographs from *Lendemer 36361*). A, thallus and perithecia. B, ascospores in iodine. C-D, asci in iodine illustrating the broad chamber in the ascus tip. E, geographic distribution of *A. gemmata* in North America based on specimens examined for this study. Scale bars = 0.5 mm in A and 20  $\mu$ m in B-D.

## NOTES

### I – SECOND NORTH AMERICAN REPORT OF *ACROCORDIA GEMMATA*

*Acrocordia gemmata* (Ach.) A. Massal., Geneac. Lich. p. 17. 1854.

FIGURE 1.

Discussion. – When Harris (1995) reported *Acrocordia gemmata* from North America he based his report on a single collection purportedly made by William W. Calkins in Jacksonville, Florida. At that time Harris considered the report questionable due to Calkins' unreliable collection practices and inconsistent numbering schemes. We were thus quite surprised by the discovery of a population in the Bull Neck Swamp Forest of Washington County, North Carolina. As was the case for Calkins' collection, the material from North Carolina was found growing on bald cypress (*Taxodium*). Based on this new collection we assert that the locality data for the original Calkins collection was likely correct, and confirm the occurrence of *A. gemmata* in North America. In the field *A. gemmata* is most likely to be mistaken for species of *Anisomeridium* with large immersed perithecia which also have 2-celled, hyaline ascospores that can be arranged uniseriately within the ascus. *Acrocordia gemmata* differs from such taxa in having asci with a distinct, broad ocular chamber (fig. 1, C and D) and ascospores that are never pointed at either end (Harris 1995).

*Specimen examined.* – U.S.A. NORTH CAROLINA. WASHINGTON CO.: Bull Neck Swamp, Deep Creek Rd. N of jct w/ Bear Lane, 23.iii.2013, on *Taxodium*, J.C. Lendemer et al. 36361 (NY).

### II – DISCOVERY OF FERTILE MATERIAL OF *HEIOMASIA SEAVEYORUM*

*Heiomasia seaveyorum* Nelsen & Lücking, Bryologist 113(4): 748. 2010.

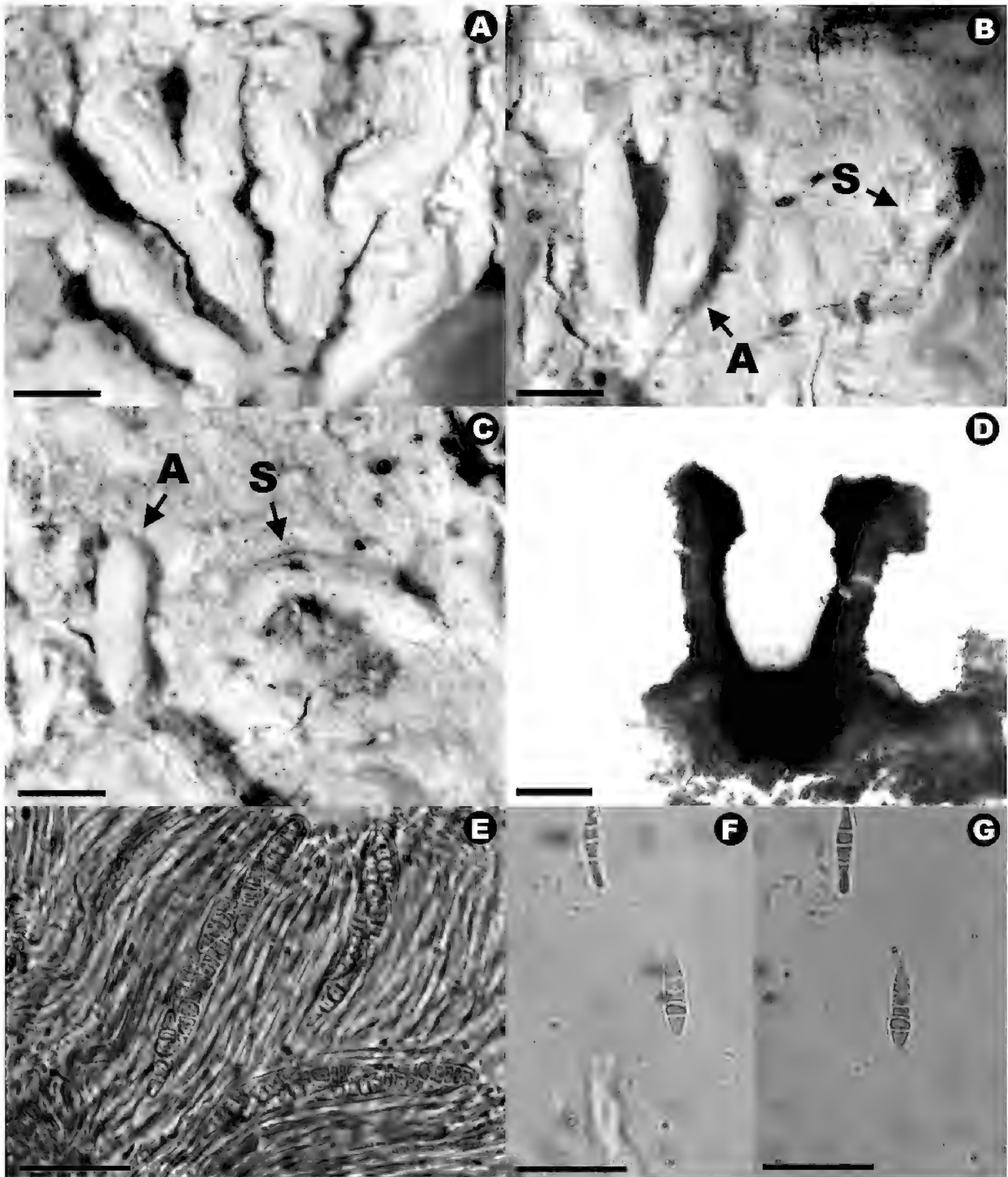
FIGURE 2.

Discussion. – The genus *Heiomasia* Nelsen & Lücking was described by Nelsen et al. (2010) to accommodate two sterile, asexually reproducing lichens with unusual lichenized diaspores. Despite having highly morphologically divergent lichenized diaspores, the species were placed together in a single genus on the basis of molecular data that recovered them as a strongly supported clade of uncertain position within the Graphidaceae s.l. (i.e., including Thelotremaaceae) (Nelsen et al. 2010). In a subsequent study aimed at resolving the phylogeny of the Graphidaceae s.l., Rivas Plata et al. (2013) recovered *Heiomasia* as a member of the Graphidoideae with support and resolved in an unsupported clade in a supported sister relationship to a clade containing Thelotremoid genera such as *Melanotopelia* Lumbsch & Mangold, *Schizotrema* Mangold & Lumbsch, and *Topeliopsis* Kantvilas & Vězda.

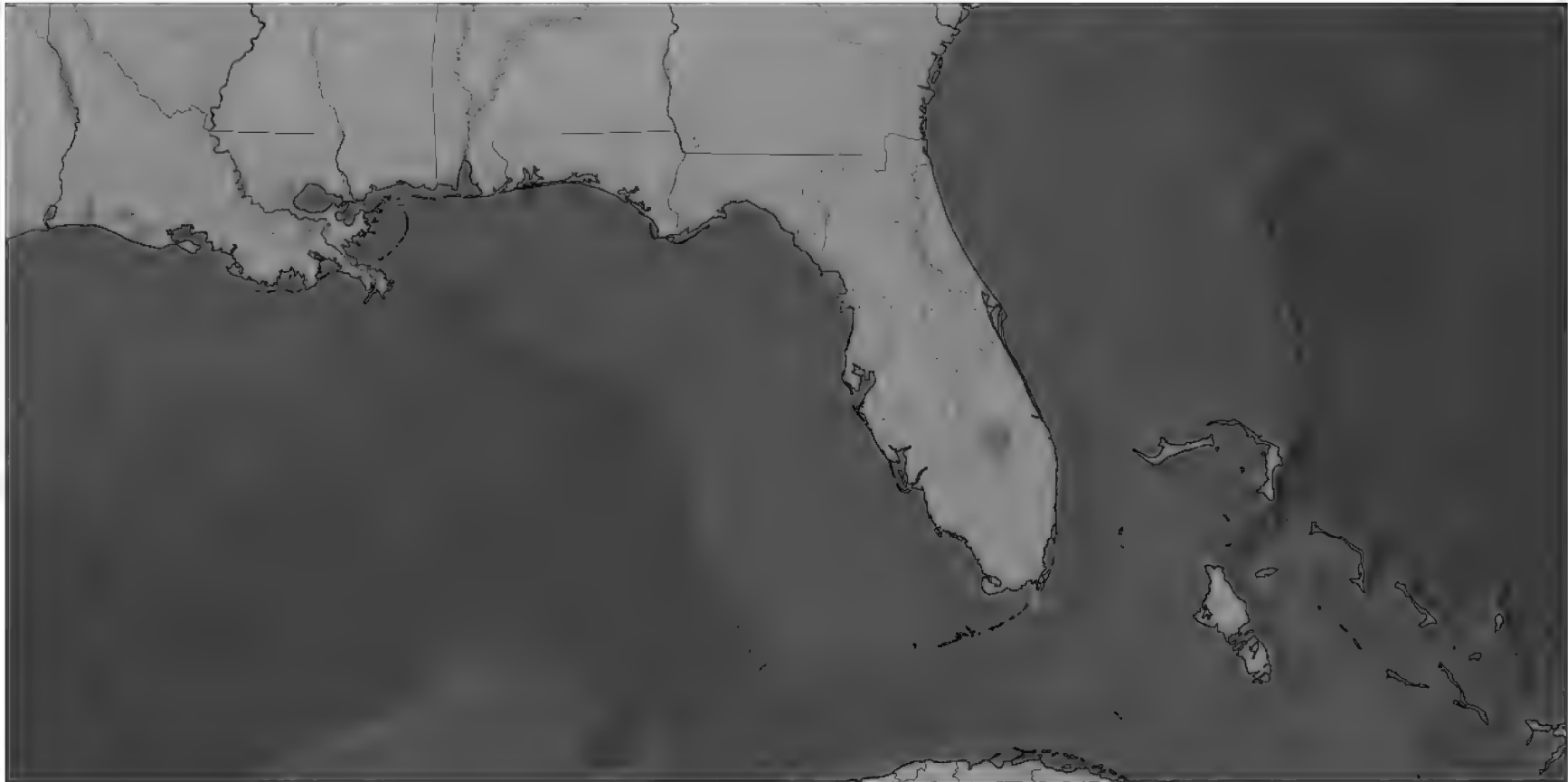
*Heiomasia* has been hypothesized to represent a “relict clade with no close extant relative” (Rivas Plata et al. 2013: 83) and considered “enigmatic” due to its persistent sterility. One of the species of *Heiomasia*, *H. seaveyorum* Nelsen & Lücking was initially considered narrowly endemic to tropical southern Florida (Nelsen et al. 2010). Later Lendemer (2011a) showed that the species actually occurs as far north as northern Florida, indicating that while rare, it is likely more widespread than previously thought. Recently, while examining undetermined Graphidaceae from the Coastal Plain at NY we came across a large collection of *H. seaveyorum* that was abundantly fertile.

The discovery of fertile material of *H. seaveyorum* raises interesting questions about its relationships within the Graphidaceae. The fruiting bodies (fig. 2A) strongly resemble those of *Carbacanthographis* Staiger & Kalb in having branched lirellae with a carbonized exciple and complete thalline covering (Staiger 2002). Despite the abundance of lirellae in our material, we were unable to confirm with certainty the presence of ornamented periphysoids lining the thalline covering inside the labia just above the exciple. In addition to sharing characters of the fruiting bodies, the ascospores (fig. 2) of *Heiomasia* are hyaline and I-, much like those of *Carbacanthographis*. The most significant differences between *Carbacanthographis* and *Heiomasia* are the thick, ecorticate thallus and production of isidium-like lichenized diaspores in the latter. Interestingly both genera were supported as members of the Graphidoideae in the analyses performed by Rivas Plata et al. (2013). Although Rivas Plata et al. (2013) recovered *Heiomasia* in a clade with *Melanotopelia*, *Schizotrema*, and *Topeliopsis* this relationship was not supported. Similarly, even with limited taxon sampling across *Carbacanthographis*, Rivas Plata et al.





**Figure 2,** *Heiomasia seaveyorum* (all from Harris 29925, NY). A, morphology of the lirellae. B and C, portion of thallus with both sexual fruiting bodies (“s”) and asexual lichenized diaspores (“a”). D, transverse section of lirella in water. E, ascus and hymenium in iodine. F-G, ascospores in water (F) and iodine (G). Scale bars = 0.5 mm in A-C, 200  $\mu$ m in D, 20  $\mu$ m in E-G.



**Figure 3**, geographic distribution of *Lecanora floridula* based on specimens at NY including the location of the report of *L. barkmaniana* (yellow star).

(2013) did not recover the genus as monophyletic and the clade comprising *C. alloafzelii* (A.W. Archer) A.W. Archer, *C. stictica* Staiger & Kalb, and *Acantothecis peplophora* (M. Wirth & Hale) E. Tripp & Lendemer was unsupported. Considering that *Carbacanthographis* and *Heiomasia* were separated only by short branches without support in the phylogeny published by Rivas Plata et al. (2013) it is tempting to speculate that the morphology of the lirellae may indicate a previously unrecognized close relationship between the two genera. Here we illustrate the fruiting bodies and ascospores of *H. seaveyorum* for the first time, hopefully stimulating further study of this unusual North American endemic.

*Specimen examined.* – **U.S.A. FLORIDA.** COLLIER CO.: Fakahatchee Strand State Preserve, Royal Palm Hammock, 5.7 mi from S entrance on W.J. Janes Memorial Scenic Drive, 6.xii.1992, on *Quercus*, R.C. Harris 29925 (NY).

### III – PREVIOUS REPORT OF *LECANORA BARKMANIANA* IS BASED ON A MISIDENTIFICATION OF *L. FLORIDULA*

*Lecanora floridula* Lumbsch in Lumbsch, Feige and Elix, Bryologist 98(4): 569. 1995.

**FIGURE 3.**

**Discussion.** – *Lecanora barkmaniana* Aptroot & Herk is a corticolous member of the *L. subfusca* group that was described from Europe and has not subsequently reported from elsewhere (Aptroot & van Herk 1999). It is a corticolous species that has a sorediate thallus and produces atranorin and zeorin (Aptroot & van Herk 1999). Recently, Kaminsky et al. (2013) reported *L. barkmaniana* for the first time from North America based on a collection from subtropical Florida that had been identified by André Aptroot in 2009.

Initially we were skeptical of this report because the illustration of *Lecanora barkmaniana* published by Kaminsky et al. (2013) seemed to show a thallus with yellowish-green soredia which suggested the presence of usnic acid. In this respect the illustration strongly resembled *L. floridula* Lumbsch, another sorediate member of the *L. subfusca* group that produces usnic acid as the major secondary metabolite instead of atranorin and zeorin. Indeed, the report of *L. barkmaniana* is within the known range of *L. floridula* (fig. 3).

In order to resolve this problem we queried Roger Rosentreter who generously sent a later collection identified as *Lecanora barkmaniana* that had been made at the same site as the original report. Morphological and chemical study of the specimen confirmed that it contained usnic acid as the major

substance and represented *L. floridula* not *L. barkmaniana*. Since the specimen we examined was not from the same collection as that identified by Aptroot, we also borrowed a duplicate of that collection that had been deposited in FLAS. The voucher identified as *L. barkmaniana* that had been deposited in FLAS also proved to be *L. floridula*. Since the reports of *L. barkmaniana* for North America were based on misidentifications of *L. floridula*, the former name should be excluded from the North American Checklist (Esslinger 2012).

*Lecanora floridula* was originally described from several localities in southern and central Florida by Lumbsch et al. (1995). It was characterized by having a sorediate thallus producing usnic acid, together with unidentified terpenoids and minor amounts of atranorin. We have examined material of *L. floridula* from near the type locality, as well as numerous specimens from throughout Florida. Although we agree with Lumbsch et al. (1995) that the species is quite distinctive, we have been unable to confirm the presence of atranorin in any of the specimens we have examined. It is possible that the substance is present in extremely low concentrations that are only detectable with HPLC, or that the concentration is variable across populations. Nonetheless, the species is easily recognized by its corticolous habit, sorediate thallus with discrete soralia, and the production of usnic acid without accessory zeorin. In the field *L. floridula* is most likely to be confused with *Buellia wheeleri* R.C. Harris (also treated as *Ciposia wheeleri* (R.C. Harris) Marbach), another corticolous lichen with yellow soredia. In that species though, the soralia arise from thin, flat green areoles and the yellow coloration is due to the presence of secalonic acid rather than usnic acid.

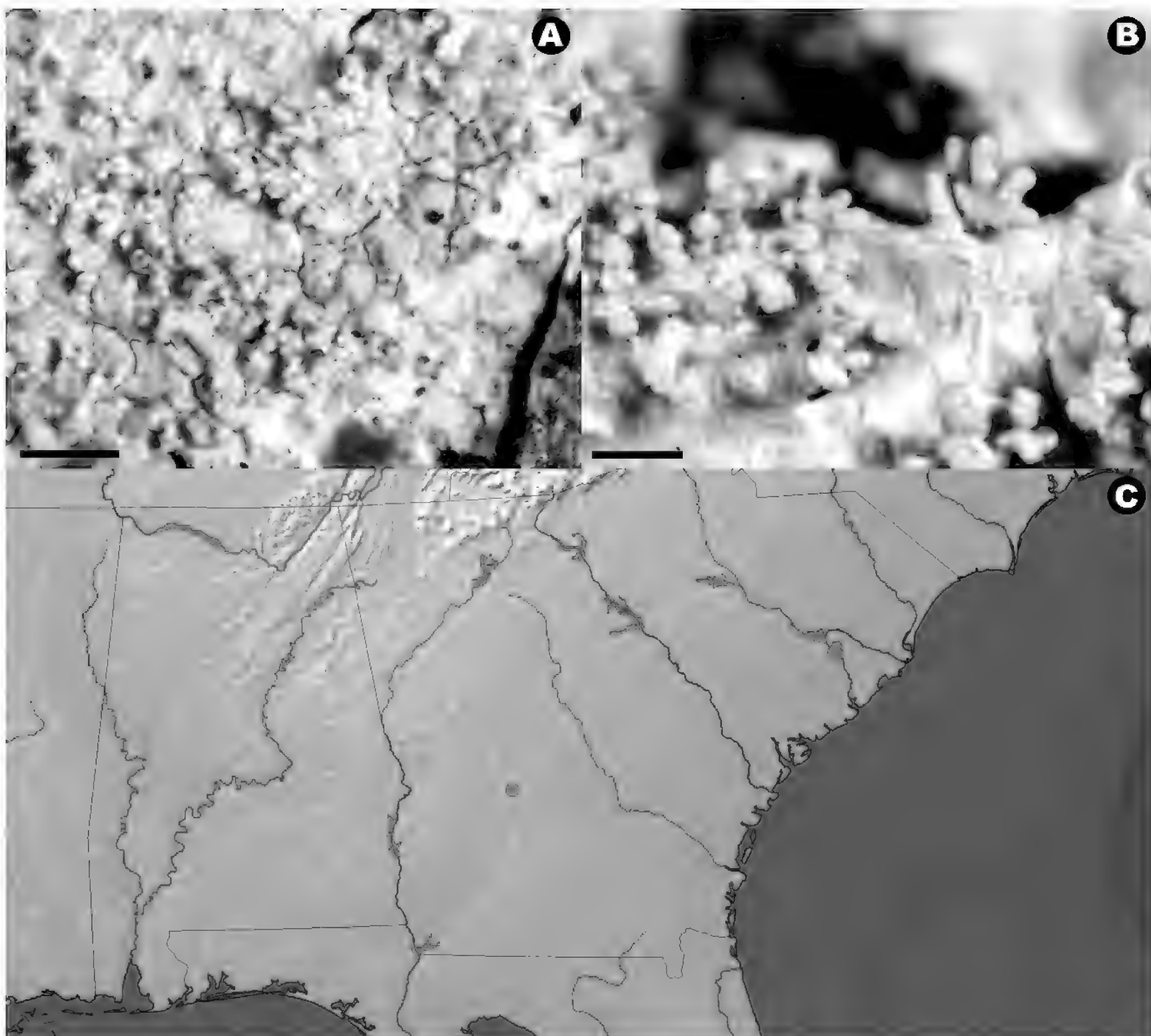
*Specimens examined.* – **U.S.A. FLORIDA.** BAKER CO.: along CR127 at Moccasin Creek, 26.xi.1996, on bark, *R.C. Harris 39297* (NY). CITRUS CO.: Oyster Shell Island on the Gulf Coast of Florida, ~5 mi W of Ozello and 200 km N of St. Petersburg, sine date, on decorticate wood, dead juniper trees, *R. Rosentreter 16425* (FLAS), *R. Rosentreter 17561* (NY). CLAY CO.: Gold Head Branch State Park, 29.xi.1992, on *Liquidambar*, *R.C. Harris 29210* (NY). COLLIER CO.: Fakahatchee Strand State Preserve, along James Memorial Scenic Drive, 4.iii.2009, on *Taxodium*, *J.C. Lendemer 15526* (NY). DIXIE CO.: Steinhatchee Wildlife Management Area, 4.ix.1993, on bark, *W.R. Buck 24348* (NY). GLADES CO.: Tom Gaskin's Cypress Catwalk, 30.iii.1998, on wood, *W.R. Buck 34100* (NY). HAMILTON CO.: Bee Haven Bay, 15.xii.1993, on *Fraxinus*, *R.C. Harris 32492* (NY). HENDRY CO.: along CR78, 0.6 mi W of SR29 at LaBelle, 27.iii.1998, on *Quercus*, *W.R. Buck 33799* (NY). HOLMES CO.: E of CR177A, 4 mi NW of SR79 in Bonifay, 10.xii.1993, on bark, *W.R. Buck 24715* (NY). HERNANDO CO.: Withlacoochee State Forest, Richloam Wildlife Management Area, 4.xii.1992, on *Nyssa*, *R.C. Harris 29794* (NY). HILLSBOROUGH CO.: Hillsborough River State Park, 3.xii.1992, on *Quercus*, *R.C. Harris 29651* (NY). LEE CO.: Caloosahatchee River State Recreation Area, 10.xii.1992, on *Quercus*, *R.C. Harris 30251* (NY). LIBERTY CO.: W of CR379, 0.9 mi NW of FL65 at Sumatra, 4.v.1990, on *Taxodium*, *R.C. Harris 25114* (NY). MONROE CO.: Key Largo, Dove Creek Hammock, 15.i.2011, on *Conocarpus erectus*, *J. Hollinger 2387* (NY). POLK CO.: Fedhaven, 25.ix.1989, on log, *E.M. Wheeler s.n.* (NY). SARASOTA CO.: Myakka River State Park, 5.xii.1992, on *Quercus*, *R.C. Harris 29845* (NY). SEMINOLE CO.: Little Big Econlockhatchee State Forest, along Florida Trail from entrance on CR426, 10.i.1996, on *Liquidambar*, *R.C. Harris 37660* (NY). SUMTER CO.: along CR330, 1.1 mi ENE of CR48, 5.xii.1996, on *Acer*, *R.C. Harris 39813* (NY). VOLUSIA CO.: Blue Spring State Park, 23.iii.1998, on *Quercus*, *R.C. Harris 41494* (NY).

#### IV – FIRST REPORT OF *OCHROLECHIA ISIDIATA* FOR NORTH AMERICA

*Ochrolechia isidiata* (Malme) Vers., Ann. Mus. Nat. Hungar., new ser., 7: 298. 1956.

FIGURE 4.

Notes. – *Ochrolechia isidiata* is a distinctive corticolous member of the genus with an isidiate thallus that typically produces lichexanthone in addition to gyrophoric and lecanoric acids (Brodo 1991). According to Brodo (1991) the species appears to be uncommon but widely distributed in the Neotropics, occurring in South America (Brazil, Paraguay), Central America (southern Mexico), and the West Indies (Dominica). Recently Malcolm Hodges sent us a specimen of an unusual isidiate lichen from the Coastal Plain of Georgia, U.S.A. The specimen proved to be the first North American record of *O. isidiata*. The species was found growing in an isolated pond cypress (*Taxodium ascendens*) depression, a habitat type that is relatively inaccessible in Georgia and thus likely under surveyed (M. Hodges pers. comm.). The collection reported here represents the chemotype of the species that produces lichexanthone.



**Figure 4, *Ochrolechia isidiata*.** A, morphology of the thallus (Hodges 8851, scale 0.5 mm). B, detail of the isidia (Hodges 8851, scale = 0.25 mm). C, location of the newly discovered population.

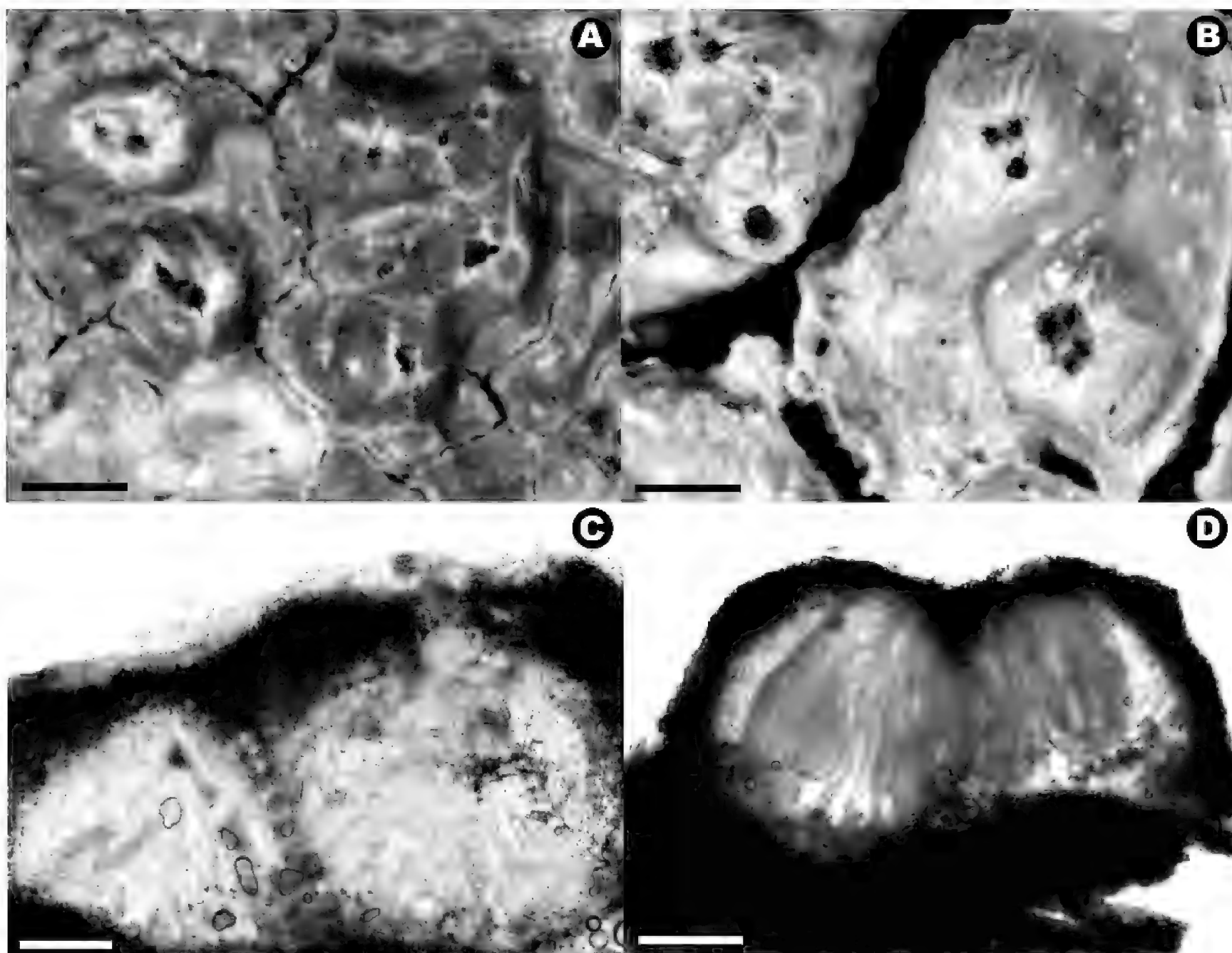
*Specimens examined.* – **U.S.A. GEORGIA.** DOOLY CO.: Oakbin Pond The Nature Conservancy Preserve, 6.ix.2012, on *Nyssa*, M. Hodges 8851 (NY). **BRAZIL. MATTO GROSSO:** zwischen Boa Vista und São Lourenço, etwa 15 km NW von Rondonopolis, 30.vi.1980, on bark, K. Kalb s.n. (NY).

#### V – THE DISTINCTION BETWEEN *PERTUSARIA OBRUTA* AND *P. SINUSMEXICANI*

#### FIGURES 5 AND 6.

**Discussion.** – Recently, while identifying material collected during our inventory of the Mid-Atlantic Coastal Plain we were puzzled by a series of specimens that superficially resembled *Pertusaria sinusmexicani* Dibben, but differed in having asci with two spores (vs. four) and lacking dense inspersion of the hymenium. Review of the extensive holdings of *P. sinusmexicani* at NY revealed the existence of similar populations from the Appalachian Mountains and elsewhere in the southeastern Coastal Plain. While preparing to formally describe these specimens as a separate taxon we made the connection with *P. obruta* R.C. Harris, a species originally described from Florida (Harris 1990) which we had presumed to be restricted to more tropical areas of southern Alabama, Georgia, and northern Florida. Revision of the material filed as *P. sinusmexicani* at NY led to the recognition that many specimens were in fact *P. obruta*, including those reported as *P. sinusmexicani* from the Great Smoky Mountains by Lendemer et al. (2013).

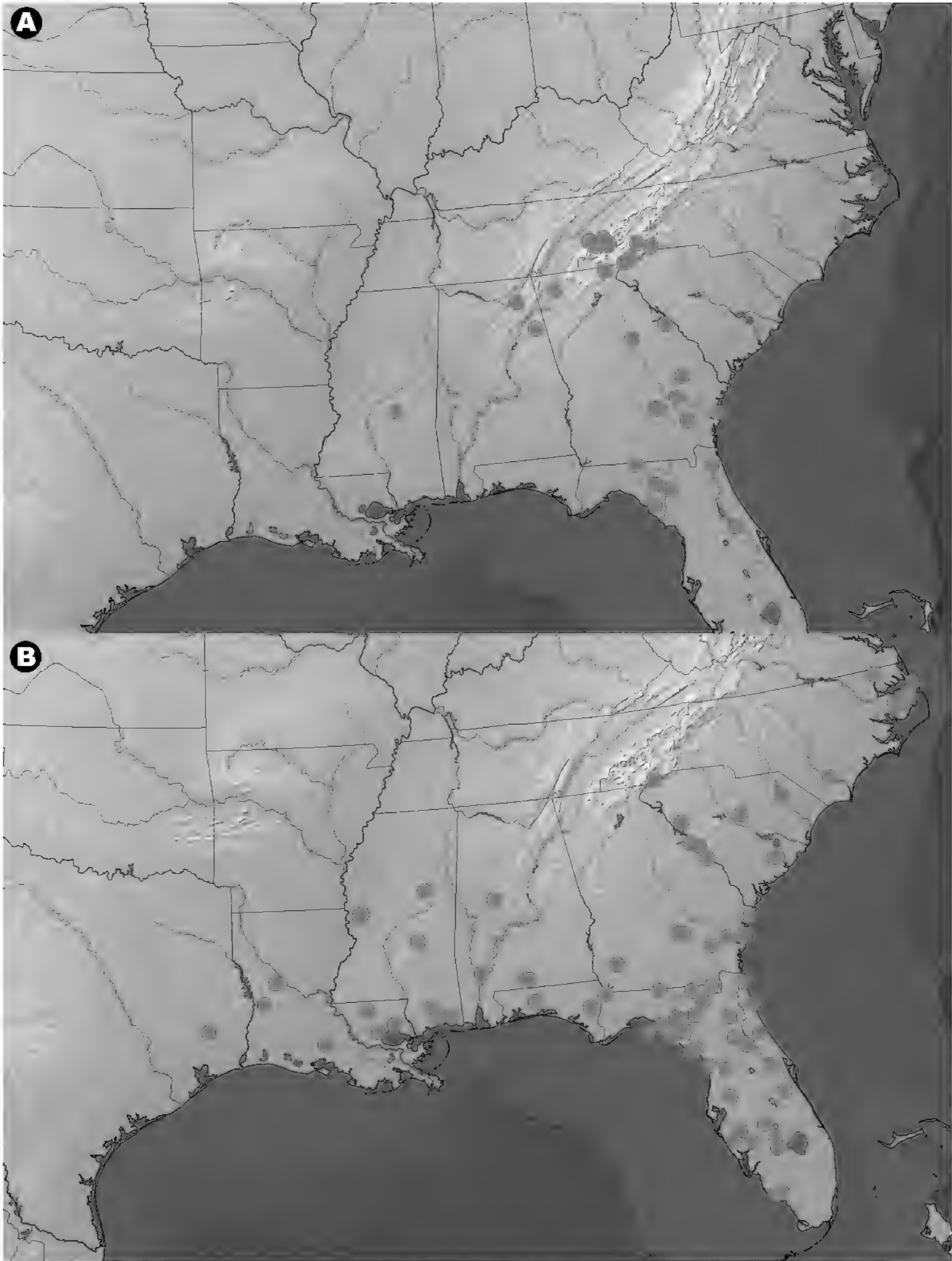




**Figure 5**, *Pertusaria obruta* (A,C) and *P. sinusmexicani* (B,D). A, morphology of the thalline warts in *P. obruta* (Lendemer 35019). B, morphology of the thalline warts in *P. sinusmexicani* (Lendemer 34232). C, cross section of thalline warts in *P. obruta* illustrating the clear, non-inspersed hymenium (Lendemer 35666). D, cross section of thalline warts in *P. sinusmexicani* illustrating the present of dense inspersed of the hymenium (Lendemer 35754). Scales = 0.5 mm in A and B, 100 µm in C, and 200 µm in D.

Despite our initial confusion, it is clear that the two species can be readily separated, even in the field. Here we present the first color illustrations and distribution maps of these taxa, as well as a list of selected specimens examined. Both species are very distinctive because of their shiny greenish-gray thalli and warts with white radiating striae. *Pertusaria sinusmexicani* can be recognized by its warts that become distinctly raised above the thallus surface (fig. 5B), densely inspersed hymenium (fig. 5D), and 4-spored asci, whereas *P. obruta* has warts that largely remain immersed in the thallus (fig. 5A), a clear hymenium (fig. 5C), and 2-spored asci. In addition to these differences in morphology, the species have markedly different geographic distribution patterns. *Pertusaria obruta* is widespread in the Atlantic Coastal Plain, extending from the Delmarva Peninsula south to central Florida and southern Georgia, inland into the Piedmont and middle to low elevations of the southern Appalachians (fig. 6A). Conversely *P. sinusmexicani* is entirely sympatric throughout the range of *P. obruta* but also widely distributed in the Gulf Coastal Plain, occurring throughout Florida and westward to Louisiana and Texas (fig. 6B).

*Selected specimens of Pertusaria obruta examined.* – **U.S.A. ALABAMA.** CALHOUN CO.: Talladega National Forest, ~1 mi SE of Nance's Creek, 22.vii.2005, on *Quercus*, C.J. Hansen 1914 (NY). DEKALB/MARSHALL CO.: Buck's Pocket State Park, 3.x.1998, on bark, W.R. Buck 34681 (NY). **FLORIDA.** COLUMBIA CO.: Ichetucknee Springs State Park, vicinity of Fig Springs, 2.xii.1992, on *Ilex*, R.C. Harris 29567 (NY). DIXIE CO.: Steinhatchee Wildlife Management Area, Pumpkin Swamp, 4.xii.1993, on *Acer*, W.R. Buck 24304 (NY). DUVAL CO.: Jacksonville, xi.1897, on bark, R. Thaxter s.n. (NY). MADISON CO.: 0.3 mi on dirt road W of CR150, 7.7 mi NNE of US90, 14.xii.1993, on Ericaceae, R.C. Harris 32394 (NY). SANTA ROSA CO.: Blackwater



**Figure 6**, geographic distributions of *Pertusaria obruta* (A) and *P. sinusmexicani* (B) based on material at NY.

River State Forest, along Jackson Red Ground Trail north from Red Rock Rd. just E of Big Juniper Creek, 9.xii.1993, on bark, *W.R. Buck* 24620 (NY). SUWANNEE CO.: Peacock Springs State Recreation Area, 2.xii.1996, on *Quercus*, *R.C. Harris* 39423 (NY). VOLUSIA CO.: Blue Spring State Park, along W French Ave., 23.iii.1998, on bark, *W.R. Buck* 33519 (NY). **GEORGIA.** APPLING CO.: Moody Forest Natural Area, 17.xii.2009, on *Liquidambar*, *J.C. Lendemer* 21085 (NY). COFFEE CO.: Broxton Rocks Ecological Preserve, High Point area, 7.x.1999, on *Quercus*, *R.C. Harris* 43576 (NY). COLUMBIA CO.: Heggie's Rock Preserve, E of Louisville Rd. ~2 mi N of GA232, 11.iii.2010, on *Juniperus*, *W.R. Buck* 55978 (NY). MCINTOSH CO.: Sapelo Island, Sapelo Island Wildlife Management Area, West Perimeter Rd. 0.5 mi N of Kenan Fields, 16.xii.2009, on *Juniperus*, *J.C. Lendemer* 20855 (NY). PIERCE CO.: Little Satilla Wildlife Management Area, 21.xii.2009, on *Acer*, *J.C. Lendemer et al.* 21464 (NY). PUTNAM CO.: Eatonton Granite Outcrop, along W shore of Oconee Lake, 8.x.1999, on *Juniperus*, *R.C. Harris* 43717 (NY). TOWNS/RABUN CO.: Chattahoochee National Forest, along Appalachian Trail between Dicks Gap Creek and Little Bald Knob, 21.ix.1992, on *Quercus*, *R.C. Harris* 28077 (NY). WALKER CO.: Chattahoochee National Forest, Johns Mountain Overlook at end of FSR208, 28.ix.1992, on *Quercus*, *R.C. Harris* 28245 (NY). **MARYLAND.** WORCESTER CO.: Pocomoke State Forest, Hickory Point Swamp, E of access road 0.5 mi N of jct w/ Hickory Point Rd., 15.xi.2012, on *Acer*, *J.C. Lendemer et al.* 33997 (NY). **MISSISSIPPI.** SCOTT CO.: Bienville National Forest, Caney Creek Wildlife Management Area, along FSR518, 29.ix.1992, on *Ulmus*, *R.C. Harris* 28768 (NY). **NORTH CAROLINA.** DARE CO.: Alligator River National Wildlife Refuge, W of Milltail Rd., 0.4 mi N of bridge at Milltail Creek, 9.xii.2012, on *Acer*, *J.C. Lendemer et al.* 34241 (NY). HENDERSON CO.: Pisgah National Forest, North Mills River Recreation Area, 30.iv.2006, on *Acer*, *J.C. Lendemer et al.* 7086 (NY). JONES CO.: Croatan National Forest, Catfish Lake South Wilderness, 0.4 mi N of Mire Branch Rd., 12.xii.2004, on *Acer*, *J.C. Lendemer* 3656 & *E. Tripp* (NY). POLK CO.: Green River Game Land, near beginning of Pulliam Creek Trail, 5.iv.2006, on *Quercus*, *W.R. Buck* 50093 (NY). SWAIN CO.: Great Smoky Mountains National Park, terminus of Lakeshore Drive to jct of Lakeshore Trail and White Oak Branch Trail, 29.vi.2010, on *Quercus*, *E. Tripp et al.* 1070 (NY); Great Smoky Mountains National Park, Sunkota Ridge Trail between Martins Gap and S spur trail to Indian Creek Trail, 21.vi.2011, on *Acer*, *J.C. Lendemer* 29407-A & *N. Davoodian* (NY). TRANSYLVANIA CO.: Gorges State Park, along road between Bearwallow River and Toxaway River, 12.viii.2005, on *Quercus*, *J.C. Lendemer* 4838 & *E. Tripp* (NY). **TENNESSEE.** BLOUNT CO.: Great Smoky Mountains National Park, Rabbit Creek Trail 0-2.7 mi E of Abrams Creek, 24.vi.2011, on *Quercus*, *J.C. Lendemer et al.* 26919 (NY), *J.C. Lendemer et al.* 29620 (NY); Great Smoky Mountains National Park, Abrams Creek Trailhead to Little Bottoms Trailhead, 30.vi.2010, on *Carya*, *J.C. Lendemer et al.* 23651 (NY).

*Selected specimens Pertusaria sinusmexicani examined.* – **U.S.A. ALABAMA.** BIBB CO.: Talladega National Forest, Oakmulgee Wildlife Management Area, 1.x.1992, on *Liquidambar*, *R.C. Harris* 28886 (NY). CLARKE CO.: Fred T. Stimpson Wildlife Sanctuary, SSE of Jackson, 31.vii.2003, on *Quercus*, *W.R. Buck* 44826 (NY). COVINGTON CO.: Conecuh National Forest, Solon Dixon Forestry Center, Blue Springs, 14.iv.2007, on *Quercus*, *R.C. Harris* 53845 (NY). ESCAMBIA CO.: Conecuh National Forest, Solon Dixon Forestry Education Center, 14.iv.2007, on *Quercus*, *R.C. Harris* 53440 (NY). **FLORIDA.** COLLIER CO.: Fakahatchee Strand State Preserve, along Janes Memorial Scenic Drive, 4.iii.2009, on *Taxodium*, *J.C. Lendemer* 15682 (NY). DIXIE CO.: Steinhatchee Wildlife Management Area, Pumpkin Swamp, 4.xii.1993, on *Quercus*, *R.C. Harris* 31552 (NY). GADSDEN CO.: Chattahoochee, "Brickyard Glade", 30.xi.1994, on *Liquidambar*, *R.C. Harris* 35629 (NY). HIGHLANDS CO.: Highlands Hammock State Park, 22.xii.1965, on bark, *C.M. Wetmore* 13917 (NY). LEVY CO.: Black Point Swamp, along CR326, 31.xii.1996, on bark, *W.R. Buck* 28734 (NY). MANATEE CO.: Upper Myakka River Watershed, on Taylor Rd. at Myakka River, 29.iii.1998, on *Nyssa*, *R.C. Harris* 42041 (NY). SANTA ROSA CO.: Blackwater State Forest, along Jackson Red Ground Trail from Red Rock Rd., 9.xii.1993, on *Cornus*, *R.C. Harris* 32048 (NY). SEMINOLE CO.: Little Big Econlockhatchee State Forest, along Florida Trail from entrance on CR426, 10.i.1996, on *Quercus*, *R.C. Harris* 37634 (NY). **GEORGIA.** BAKER CO.: Ichauway Plantation / Jones Ecological Research Center, 16.iv.2007, on *Acer*, *J.C. Lendemer et al.* 9499 (NY). COFFEE CO.: Broxton Rocks Ecological Preserve, Ricketson Tract, 18.ix.1996, on *Quercus*, *R.C. Harris* 38797 (NY). MCINTOSH CO.: Sapelo Island, R.J. Reynolds Wildlife Management Area, 16.xii.2009, on *Acer*, *J.C. Lendemer* 20911 (NY). PIERCE CO.: Little Satilla Wildlife Management Area, Knight Road ~1 mi E of Offerman, between Zero Bay and Sixty Foot Branch of Little Satilla River, 21.xii.2009, on *Acer*, *J.C. Lendemer et al.* 21479 (NY). TATTNALL CO.: Big Hammock Natural Area, 18.xii.2009, on *Quercus*, *J.C. Lendemer* 21135 (NY). WAYNE CO.: Sansavilla Wildlife Management Area, boat launch below Alex Creek, 21.xii.2009, on *Nyssa*, *J.C. Lendemer et al.* 21604 (NY). **LOUISIANA.** NATCHITOCHES PARISH: Longleaf Trail Vista, ~35 mi WNW of Alexandria, 28.v.1976, on *Magnolia*, *R.C. Harris* 11438 (NY). ST. MARY PARISH: near Franklin Chatsworth Levee, ~0.5 mi from pumping station, 12.ix.1975, on *Acer*, *W.R. Buck* B588 (NY). ST. TAMMANY PARISH: Fontainebleau State Park near Mandeville, 7.iii.1982, on *Nyssa*, *J. Pruski* 2408B (NY). VERNON PARISH: ½ mi S of Pickering, 26.vi.1964, on bark, *G.T. Johnson s.n.* (NY). **MISSISSIPPI.** HARRISON CO.: 10 mi SE of Saucier, 26.viii.1940, on bark, *G.T. Johnson* 3241A (NY). JACKSON CO.: 2 mi N of Vancleave, 15.vi.1939, on *Liriodendron*, *G.T. Johnson* 2673 & *H.N. Andrews* (NY). STONE CO.: near Perkinston, xii.1938, on bark, *G.T. Johnson* 3339 (NY). SMITH CO.: Bienville National Forest, Marathon Lake Recreation Area, 30.ix.1992, on *Quercus*, *R.C. Harris* 28791 (NY). WINSTON CO.: Tombigbee National Forest, Choctaw Wildlife Area, 29.ix.1992, on *Nyssa*, *R.C. Harris* 28659 (NY). **NORTH CAROLINA.** BLADEN CO.: N of Elwell Ferry Rd.,

~0.5 mi W of Elwell Ferry, 15.vi.2002, on *Carya*, R.C. Harris 46081 (NY). DARE CO.: Kitty Hawk Woods Coastal Reserve, 14.iv.2012, on *Cornus*, J.C. Lendemer et al. 31049 (NY). HYDE CO.: Pocosin Lakes National Wildlife Refuge, 11.xii.2012, on *Nyssa*, J.C. Lendemer et al. 34849 (NY). GATES CO.: Merchants Millpond State Park, 14.iv.2012, on *Acer*, J.C. Lendemer et al. 31168 (NY). TYRRELL CO.: Pocosin Lakes National Wildlife Refuge, S of Frying Pan Boat Access, 10.xii.2012, on *Liquidambar*, J.C. Lendemer et al. 34492 (NY). **SOUTH CAROLINA.** AIKEN CO.: Savannah River Bluffs Preserve, SW of Old Plantation Rd., 13.iii.2010, on *Acer*, J.C. Lendemer 21997 (NY). DORCESTER CO.: Summerville, 1937?, on bark, G.P. Anderson s.n. (NY). FLORENCE CO.: Back Swamp, Pee Dee River Basin, 10.v.2008, on *Myrica*, G.B. Perlmutter et al. 1573 (NY). RICHLAND CO.: Fort Jackson Army Base, Buffalo Creek Natural Area, 13.iii.1997, on *Acer*, R.C. Harris 39980 (NY). **TEXAS.** HARDIN CO.: 2 mi N of Votaw, 11.vii.1965, on bark, G.T. Johnson s.n. (NY).

## VI – FIST REPORT OF *ROSELLINIOPSIS TROPICA* FOR NORTH AMERICA

*Roselliniopsis tropica* Matzer & Hafellner, Biblthca. Lichenol. 37: 103. 1990.

Discussion. – During fieldwork on the Delmarva Peninsula in 2012 one of us (RCH) encountered a conspicuous lichenicolous fungus that formed swollen gall-like structures on thalli of *Ochrolechia africana* Vain. The species was quite distinctive in having perithecia and eight ornamented globose to lemon shaped brown ascospores arranged uniseriately within each ascus. The material easily keyed to *Roselliniopsis tropica*, a species that has not previously been reported from North America, but is widespread in the tropics (Matzer & Hafellner 1990) and also occurs in Europe (Diederich et al. 1992, Diederich & Roux 1991).

After becoming aware of this taxon, we searched all further collections of *Ochrolechia africana*, discovering it to be infrequent, but widespread throughout the Mid-Atlantic Coastal Plain. We suspect that others collecting within the range of *O. africana* will find additional populations of *Roselliniopsis tropica*, supplementing the distribution documented herein. Many populations of *O. africana* that we observed were only sparsely infected by *R. tropica*, particularly on the margins of the apothecia and near the periphery of thallus.

*Specimens examined.* – **U.S.A. DELAWARE.** SUSSEX CO.: Delaware Wild Lands, Great Cypress Swamp, Hudson Rd./418 ~0.6 mi S of Cypress Rd./DE54, 14.xi.2012, on *Ochrolechia africana* on canopy of fallen *Chamaecyparis*, J.C. Lendemer et al. 33746 (NY). **MARYLAND.** WORCESTER CO.: Pocomoke State Forest, S of S end of TNC Furnace Town parking area, 15.xi.2012, on *O. africana* on fallen branch, R.C. Harris 58005 (NY). **NORTH CAROLINA.** DARE CO.: Alligator River National Wildlife Refuge, W of Brier Hall Rd., 1.6 mi N of jct w/ US64, 8.xii.2012, on *O. africana* on *Acer* branch, J.C. Lendemer 34077-A (NY). TYRRELL CO.: Pocosin Lakes National Wildlife Refuge, Frying Pan Boating Access, 10.xii.2012, on *O. africana* on *Acer* branch, R.C. Harris 58362-C (NY).

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# *Lepraria brodoi* (Stereocaulaceae, lichenized Ascomycetes), a new species from the temperate rainforests of western Canada and southeastern Alaska, U.S.A.

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**ABSTRACT.** – *Lepraria brodoi* is described as new to science. The species is narrowly endemic to temperate rainforests of the Haida Gwaii (Queen Charlotte Islands) in British Columbia, Canada, and Kuiu Island, Alaska, U.S.A. It is characterized by having dark rhizohyphae, a thick hypothallus, tendency of the granules to form large aggregations on the thallus surface, and the production of alectorialic acid usually with psoromic and/or porphyritic acids.

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## INTRODUCTION

The genus *Lepraria* Ach. was long considered a taxonomically difficult group, and used as a catch-all for persistently sterile, asexually reproducing lichens with leprose thalli. Although recognized as polyphyletic over a decade ago (Ekman & Tønsberg 2002) it is only recently that studies, with the aid of molecular phylogenetic analyses, have begun to resolve the higher level taxonomy of many groups within the genus (Nelsen et al. 2008, Lendemer & Hodkinson 2013). Concurrently increased attention in the field, laboratory, and herbarium has led to more evolutionarily accurate and conceptually consistent circumscriptions for many species (Crespo et al. 2006; Fehrer et al. 2008; Lendemer 2011a, 2012a & b, 2013a; Tretiach et al. 2009).

In the context of the above efforts we conducted extensive studies of *Lepraria* in Europe and North America culminating in two major treatments for the group (Lendemer 2013b, Tønsberg 1992). During this and later work on the genus we both encountered an unusual and distinctive species with alectorialic acid in material from the temperate rainforests of the Queen Charlotte Islands of western Canada. Narrowly endemic species appear to be rare in *Lepraria*, and thus the existence of this species was a surprise. Although sharing the main chemical constituent with the widespread species *L. eburnea* J.R. Laundon, the material from the Queen Charlotte Islands differs markedly in morphology from that species. As such we formally describe the material here as *Lepraria brodoi*.

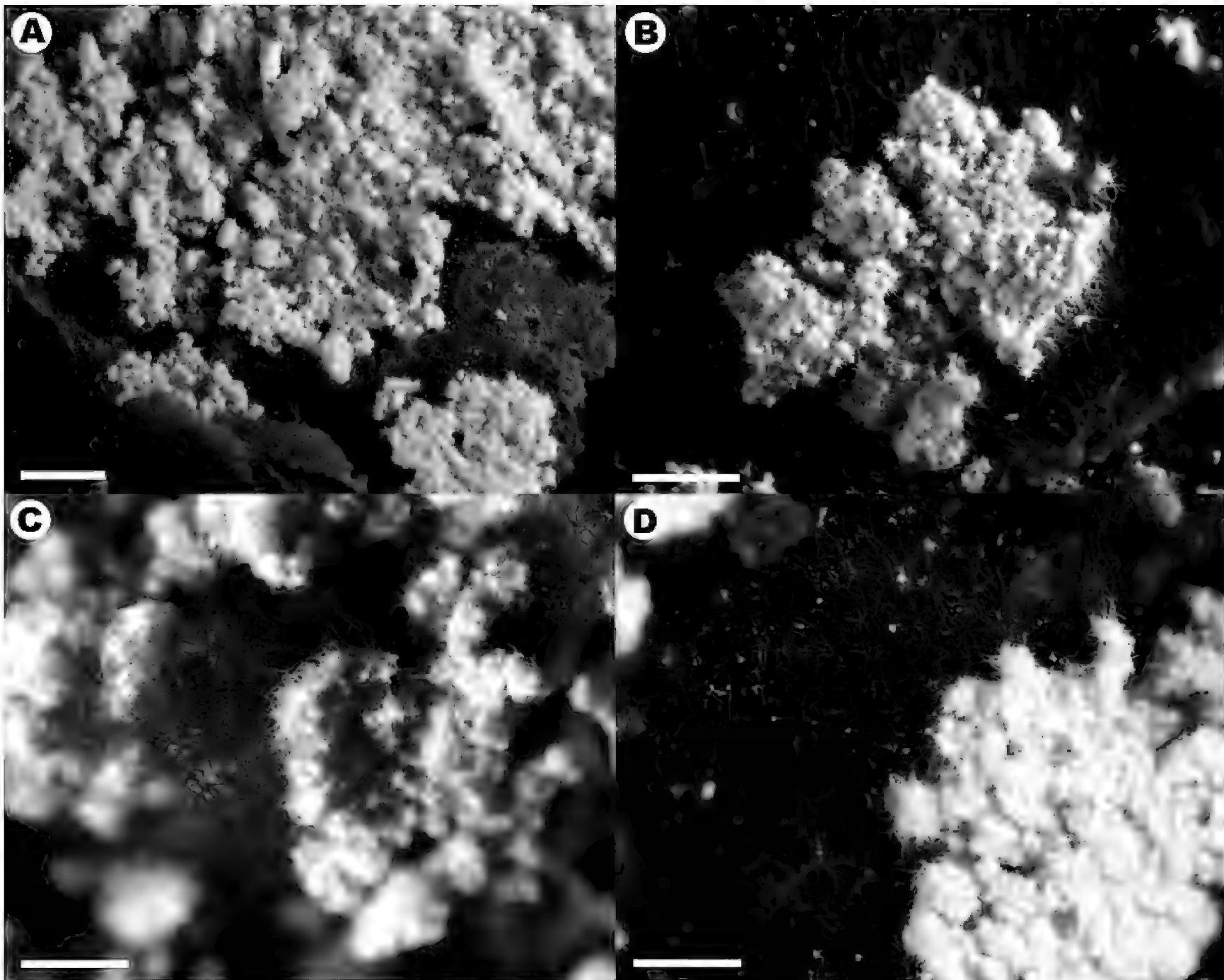
## MATERIALS AND METHODS

This study is based on specimens deposited in the herbarium of the University of Bergen (BG), Canadian Museum of Nature (CANL) and New York Botanical Garden (NY). Morphological investigations were carried out following the methods described in detail by Lendemer (2013b). Morphological descriptive terminology follows Lendemer (2011b). Size ranges of the granules, hyphae, and photobiont cells are expressed as the average  $\pm$  1 standard deviation and bounded by the smallest and largest observed values (i.e., [smallest observed value]-(average-1SD)-average-(average+1SD)-[largest observed value]).

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**Figure 1**, morphology of *Lepraria brodoi*. A, gross morphology of thallus where weft of rhizohyphae is poorly developed except in the lower right thallus (Shaw 9112). B, gross morphology of thallus where weft of rhizohyphae is well developed (Shaw 9207). C, detail of rhizohyphae not forming a conspicuous weft (Shaw 9112). D, detail of rhizohyphae forming a conspicuous weft and the thallus margin (Shaw 9112). Scales = 1.0 mm in A, 0.5 mm in B–D.

The chemistry of material used in this study was studied using standard spot tests (Brodo et al. 2001) and thin layer chromatography (TLC). TLC at BG was performed according to Culberson and Kristinsson (1970) and later modifications; all 3 solvents were used. *Allantoparmelia alpicola* (alectorialic acid), *Cladonia macrophylla* (psoromic acid), and *Haematomma ochroleucum* (porphyritic acid) were extra standards. TLC performed at NY utilized solvents A and C and the methods of Lendemer (2011c) using the porphyritic acid chemotype of *L. neglecta* as one standard and *Fissurina columbina*, which produces psoromic acid, as a second standard.

### THE NEW SPECIES

***Lepraria brodoi* Lendemer & Tønsberg sp. nov.**

Mycobank #808283.

**FIGURES 1 AND 2.**

**DIAGNOSIS.** – Differing from *Lepraria eburnea* in the production of psoromic and/or porphyritic acid, dark rhizohyphae that often form a well-developed weft, and the tendency for the granules to form large aggregations on the thallus surface.



**Figure 2**, comparison of the geographic distributions of *Lepraria brodoi* (left) and *L. eburnea* (right) in the Pacific Northwest based on specimens examined for this study and for Lendemer (2013b).

**TYPE: CANADA. BRITISH COLUMBIA. HAIDA GWAI (QUEEN CHARLOTTE ISLANDS):** Moresby Island, head of Slim Inlet, along east shore, 52°16'N 131°19'W, elev. 15.2 m., along shore and in open *Pinus–Chamaecyparis* bog to south, 04.vii.1971, on *Thuja plicata* in forest, *I.M. Brodo 17752* & *P.Y. Wong* (CANL-107415, holotype). [TLC: alectorialic (major) and psoromic acids (chemotype II).]

**DESCRIPTION.** – **Thallus** crustose, leprose, placodioid without crisped margins, continuous and distinctly bi-layered, initially forming small discrete thalli which expand marginally, overlap, and become confluent to form a thick crust (0.2–0.5 mm thick), gray with a yellowish tint in color; **hyphae** hyaline or pigmented, [2.2]–(2.7)–3.2–(3.7)–[4.9]  $\mu\text{m}$  wide ( $n=80$ ), septate, secund, obscured by a layer of POL+ crystals that do not dissolve in KOH; **prothallus** disappearing with age; **hypothallus** a variably developed layer of loosely intertwined hyphae surrounding and subtending the granules, extending outward from the edge of the thallus; **rhizohyphae** present, typically abundant, pigmented brown, often forming a distinct brown to black weft; **granules** globose, [20]–(24)–31–(38)–[57]  $\mu\text{m}$  in diameter ( $n=104$ ), ecorticate, well organized and discrete, often forming large compound units, sometimes separating from the hypothallus and then producing abundant projecting hyphae; **photobiont** green, coccoid, cells globose, [4.1]–(5.4)–6.3–(7.1)–[8.3]  $\mu\text{m}$  in diameter ( $n=82$ ).

**ETYMOLOGY.** – The epithet of the new species honors our friend and colleague the Canadian lichenologist Irwin “Ernie” Brodo (b. 1935). Ernie was born in New York City and has made significant contributions to our knowledge of the lichens of the Queen Charlotte Islands and more broadly to North America as a whole. These include the publication of the classic *Lichens of Long Island* (Brodo 1968) and the widely used *Lichens of North America* (Brodo et al. 2001) that has inspired many. It is only fitting that



a narrow endemic of the temperate rainforests of western North America, one of the most beautiful and striking species of *Lepraria* known, be named in honor of Ernie.

CHEMISTRY. – All specimens examined produced alectorialic (usually with a satellite substance) together with either psoromic acid, porphyritic acid, or both psoromic and porphyritic acids. Thus there are three chemotypes: I) alectorialic acid, psoromic acid and porphyritic acid (6 specimens); II) alectorialic acid and psoromic acid (8 specimens); III) alectorialic acid and porphyritic acid (1 specimen). Spot tests: K-, C-, KC+ red, P+ yellow, UV-.

ECOLOGY AND DISTRIBUTION. – *Lepraria brodoi* has been found in a diverse array of habitats in the Pacific Northwest. These habitats include island shores near upper tide line, different inland forests (an *Alnus-Picea* grove, a relatively old *Tsuga heterophylla-Picea sitchensis-Thuja plicata* forest, an *Pinus-Chamaecyparis* bog), and a subalpine *Tsuga heterophylla-Picea sitchensis* forest with meadows, in boggy, rock outcrop areas and in a swampy depression near a creek. It occurs on mossy rock walls and overhangs, on rotten wood and humus over igneous rock outcrops, on moist, rotten bark of stumps, and on mossy trunks, rarely directly on bark, of *Alnus rubra* (the most common phorophyte), *Thuja plicata*, *Chamaecyparis nootkatensis*, and *Picea sitchensis*. The vertical distribution ranges from about sea level to 695 m.

The species appears to be endemic to the Pacific Northwest (figure 2) where it is presently known from Haida Gwaii (Queen Charlotte Islands), British Columbia, Canada, in addition to one locality on Kuiu Island, southwestern Alaska, U.S.A. It is uncertain if it is best characterized as a temperate rainforest species or a hyper-maritime species. Nonetheless, it is certainly moisture dependent.

CONSERVATION STATUS. – This species appears to be one of two narrowly distributed members of the genus in North America; the other is *Lepraria lanata* Tønsberg, which is restricted to the southern Appalachian Mountains. It is known only from extant populations on Haida Gwaii and from two historical collections that were made in southeastern Alaska. The restricted distribution of *L. brodoi* contrasts strongly with those of such common and widespread Pacific Northwest species as *L. torii* T. Sprib. & Perez-Ort. and *L. pacifica* Lendemer. Although *L. brodoi* appears to be not uncommon on Haida Gwaii, we believe that it may warrant conservation measures to preserve existing habitats from future development and disturbance.

DISCUSSION. – *Lepraria brodoi* is a very distinctive species (figure 1) that is easily separated from its congeners by typically having a well-developed web of dark rhizohyphae, thick hypothallus, granules that tend to form large aggregations on the thallus surface, and production of alectorialic acid together with psoromic acid and/or porphyritic acid. The new species is most likely to be confused with *L. eburnea*, which is sympatric (see figure 2), also produces alectorialic acid and has a thick hypothallus (Lendemer 2013b). That species differs morphologically in lacking rhizohyphae, and in having granules that do not typically form large aggregations on the thallus surface. *Lepraria brodoi* also differs from *L. eburnea* in the frequent production of porphyritic acid in addition to alectorialic acid, as well as the frequent production of traces of psoromic acid. In most specimens examined all three of these substances were present, but in occasional specimens either psoromic acid or porphyritic acid was lacking. Orange (1997) reported a chemotype of *L. eburnea* that produces both alectorialic acid and psoromic acid. Although most of the cited collections of that chemotype were from the United Kingdom, a single specimen from Kuiu Island in Alaska was also included. We suspect that the latter specimen corresponds to *L. brodoi*. It is also plausible that the European material of this chemotype reported by Orange (1997) should be referred to *L. brodoi*, but further study is needed to determine whether that is the case.

*Lepraria neglecta* (Nyl.) Erichsen is another species that is chemically similar to *L. brodoi* in having some chemotypes that produce alectorialic acid. The chemical variation within *L. neglecta* was summarized by Lendemer (2013a) who recognized five chemotypes that produce that substance. None of the chemotypes of *L. neglecta* are known to produce alectorialic acid and psoromic acid together. Only one of the chemotypes is similar to *L. brodoi* in producing alectorialic acid together with porphyritic acid. Nonetheless the two species can easily be recognized morphologically because *L. neglecta* differs markedly from *L. brodoi* in having a thin, aggregate thallus with compact (vs. fluffy) granules, an inconspicuous prothallus composed of hyaline hyphae, and in occurring in exposed (vs. sheltered) microhabitats.

The new species also morphologically resembles *Lepraria vouauxii* (Hue) R.C. Harris, another sympatric species with a placodioid thallus that typically has a yellowish hue. That species does not produce rhizohyphae and produces pannaric acid 6-methylester instead of alectorialic acid together with psoromic and porphyritic acids.

Another species that is morphologically very similar to *Lepraria brodoi* is *L. yunnaniana* (Hue) Zahlbr., which is distributed in montane regions of South America, southeast Asia, Africa, and Australasia (Saag et al. 2009). Like *L. brodoi*, *L. yunnaniana* also has a placodioid thallus with a well developed hypothallus and dark rhizohyphae that tend to form a well developed weft (Lendemer 2011a, b; Saag et al. 2009). Nonetheless it differs significantly from *L. brodoi* in chemistry, as *L. yunnaniana* produces divaricatic acid and nordivaricatic acid rather than alectorialic acid together with psoromic and/or porphyritic acid (Lendemer 2011a). Additionally *L. yunnaniana* is known neither from the Pacific Northwest nor from North America.

*Specimens of chemotype I examined.* – **CANADA. BRITISH COLUMBIA. HAIDA GWAIH (QUEEN CHARLOTTE ISLANDS):** Moresby Island, slope above S side of unnamed lake between Mud and Peel Inlets (‘Apotreubia Lake’), elev. 150 m., 8.v.2010, peeling mossy base of tree, *B. Shaw 9112* (NY), base of rotten decorticated *Thuja*, *B. Shaw 9109* (NY); Moresby Island, Tasu Mountain, above mine, elev. 695.0 m, *Tsuga heterophylla*–*Picea sitchensis* forest on slope and subalpine meadows, 04.viii.1968, moist crevice wall, *I.M. Brodo 14292* (CANL 107413); Graham Island, ~8 air km NW of Queen Charlotte City, along logging road off of Hanny Forest Rd., elev. 500 m., 10.v.2010, on vertical side of mossy *Chamaecyparis nootkatensis* trunk, *B. Shaw 9277* (NY); Graham Island, S side of Kano Inlet, N-facing slope above a lake, elev. 200 m., 9.v.2010, vertical rock outcrop, under an overhang, *B. Shaw 9207* (NY); Graham Island, Masset area, Tow Hill, upper outlook, elev. 120 m., 13.v.2010, moist rotten bark of stump, *B. Shaw 9415* (NY); Graham Island, Dawson Inlet, near its head, elev. 13.7 m., shoreline and adjoining forest, bog, rock outcrop area, east side of inlet, 20.vi.1967, on base of tree, *I.M. Brodo et al. 10098* (CANL 107406); Graham Island, Carew Bay Mountain, avalanche slope, forest and subalpine meadow leading to summit, elev. 518.2 m, 22 .vi.1967, on base of *Chamaecyparis* on ridge, *I.M. Brodo et al. 10262* (CANL 107409); Ellen Island, 0–5 m, on shaded, 25.vii.2003, moist rock wall near upper tide line, *T. Tønsberg 32276* (BG, UBC); Gordon Island, 23.vii.2003, muscicolous on shaded rock wall, *T. Tønsberg 32126* (BG; chemotype I pro parte). **U.S.A. ALASKA:** Kuiu Island, Washington Bay, growing on moss, 15.vii.1948, *W.J. Eyerdam 408* (CANL 47449).

*Additional specimens of chemotype II examined.* – **CANADA. BRITISH COLUMBIA. HAIDA GWAIH (QUEEN CHARLOTTE ISLANDS):** Gordon Island, 23.vii.2003, muscicolous on shaded rock wall, *T. Tønsberg 32126* (BG; chemotype II pro parte); Graham Island, W of Queen Charlotte city, along Tarundl Creek, swampy depression near creek, 15.vii.1967, on *Alnus rubra*, *I.M. Brodo 11632* & *M.J. Shchepanek* (CANL 107411), on *Thuja*, *I.M. Brodo et al. 10101* (CANL 107407); Graham Island, off road to Rennell Sound, along Elk Main, near Survey Creek, fairly old *Tsuga heterophylla*–*Picea sitchensis*–*Thuja plicata* forest, 18.vii.2000, on *Alnus rubra* in forest, *I.M. Brodo et al. 30240* (CANL); Moresby Island, at the head of Newcombe Inlet (off Tasu Inlet) the mouth Tasu Creek, open, grassy, tidal meadow bordered by *Picea sitchensis*, and *Tsuga heterophylla*, 5.viii.1968, on shaded spruce trunk, *I.M. Brodo et al. 14325* (CANL 103502); Moresby Island, along Deena River, 3.vii.1967, in *Alnus*–*Picea* grove, *I.M. Brodo et al. 10859* (CANL 13504). **U.S.A. ALASKA:** Kuiu Island, Washington Bay, 25.viii.1947, on moss on cliff wall, *W.J. Eyerdam 444* (CANL 47448).

*Specimens of chemotype III examined.* – **CANADA. BRITISH COLUMBIA. HAIDA GWAIH (QUEEN CHARLOTTE ISLANDS):** Graham Island, Athlow Bay, Goose Cove, elev. 0 m., 6.v.2010, rotten wood and humus over igneous rock outcrop at beach, *B. Shaw 9025* (NY).

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## A new lichenicolous *Heteroplacidium* (Verrucariaceae) from the deserts of southern California

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**ABSTRACT.** – *Heteroplacidium transmutans* is described from the Sonoran and Mojave Deserts in southern California. It is a lichenicolous lichen that is a juvenile fungal parasite on the common yellow crustose lichen *Acarospora socialis*. The species eventually develops an independent lichenized thallus that is epilithic on granite.

**KEYWORD.** – Anza Borrego, Joshua Tree National Park, parasites, morphology, taxonomy.

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### INTRODUCTION

Lichenicolous lichens have evolved an interesting solution to the problem of a fungus finding a suitable alga for the lichen symbiosis. They have a two-stage life cycle. They begin as juvenile fungal parasites on lichens, which already have a photobiont, and eventually morph out of the thallus of the host, developing an independent and distinct lichenized thallus usually with the purloined alga of the host. This life style has evolved in many different Ascomycete lineages (Kocourková et al. 2012; Knudsen et al. 2013b). Lichenicolous lichens are frequent in some genera, with *Rhizocarpon* DC. being an outstanding example (Poelt 1990). They can be obligate on a particular host species or genus like *Lecanora thallophila* H. Magn. on *Dermatocarpon americanum* Vain. in the Grand Canyon of Arizona (Ryan et al. 2004) or *Dimelaena lichenicola* K. Knudsen, Sheard, Kocourk. & H. Mayr. on *D. oreina* (Ach.) Norman and *D. thysanota* (Tuck.) Hale & W.L. Culb. in the mountains of California and Italy (Knudsen et al. 2013b). Others appear to be only occasionally lichenicolous, like *Acarospora succedens* H. Magn. in the Sonoran Desert Region, which though described as parasitic on associated saxicolous lichens, is usually non-parasitic (Knudsen 2011).

In his revision of the European squamulose taxa of Verrucariaceae with simple ascospores and an absence of hymenial algae (at that time treated entirely within genus *Catapyrenium*), Breuss (1990) proposed six informal groups based on pycnidial types, position of the perithecia related to the squamules, the presence/absence of an involucrellum, the formation of attachment organs, carbonization/non-carbonization of the exciple, shape of asci, arrangement of the spores with the asci, and thallus anatomy. Later, these species groups were raised to generic level (Breuss 1996), and recent molecular analyses (Gueidan et al. 2007, 2009; Prieto et al. 2010a and b, 2012) have confirmed this treatment. These later studies have shown that members of *Catapyrenium* s. lat. are distributed in different lineages across the family Verrucariaceae. The genus *Heteroplacidium* Breuss has been emended to also include crustose, areolate species (Gueidan et al. 2007) and is characterized by an almost completely paraplectenchymatous thallus, clavate asci with biseriate spores, and *Dermatocarpon*-type pycnidia. *Heteroplacidium* has a less complex thallus anatomy than the otherwise similar genus *Placidium*. At present 11 species of

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*Heteroplacidium* are recognized (Breuss 2010, Prieto et al. 2012), most of which are autonomous lichens, but three are obligate parasites or facultatively lichenicolous: *H. compactum* (A. Massal.) Gueidan & Cl. Roux, *H. fuscum* (Nyl.) Gueidan & Cl. Roux, and *H. zamenhofianum* (Clauzade & Roux) Cl. Roux.

Lichenicolous lichens are frequent within the family Verrucariaceae, occurring in several genera including *Heteroplacidium*, *Placocarpus* Trevis., *Placopyrenium* Breuss, and *Verrucaria* Schrad. (Breuss 2007, 2009; Gueidan et al. 2007, 2009; Knudsen et al. 2009; Navarro-Rosinés et al. 2007). Here we describe *H. transmutans*, a fourth lichenicolous lichen belonging to the genus *Heteroplacidium*. The new species is a specialized parasite on *Acarospora socialis* H. Magn., which is common in the deserts of southwestern North America. The most outstanding feature of *H. transmutans* is that its squamules are formed by morphing out of the squamules of the host. Currently 21 species of lichenicolous lichens are known from the state of California (Kocourková et al. 2012; Knudsen et al. 2013a & b) and the present contribution adds to our growing knowledge of these organisms in the region.

## METHODS

Specimens were examined from NY, UCR, and the Herbarium Mycologicum of Jana Kocourková and Kerry Knudsen (abbreviated Hb. Kocourková & Knudsen throughout the manuscript). Handmade sections were studied in water and 10% K and lactophenol cotton blue (LPB). A solution of 70% nitric acid was used to dissolve part of the large and small crystals in the medulla of *Heteroplacidium transmutans* and *Acarospora socialis* for better observation and comparison of medullary hyphae. Amyloid reactions were tested in Lugol's iodine 1% with and without pre-treatment with K 5% K/I. Ascospore and conidia measurements were made in water with accuracy of 0.5 µm and given in the form “(minimum observed value–) average minus one standard deviation–average–average plus one standard deviation (–maximum observed value)” rounded to nearest 0.5 microns and followed by the number of measurements (n); the length/breadth ratio of ascospores is indicated as l/b and given in the same way. Macro- and microphotographs were taken with an Olympus DP72 digital camera on an Olympus SZX 7 stereomicroscope and an Olympus BX 51 fitted with a Nomarski differential interference contrast.

## TAXONOMIC SECTION

***Heteroplacidium transmutans* K. Knudsen, Breuss & Kocourk. sp. nov.**

Mycobank #808464.

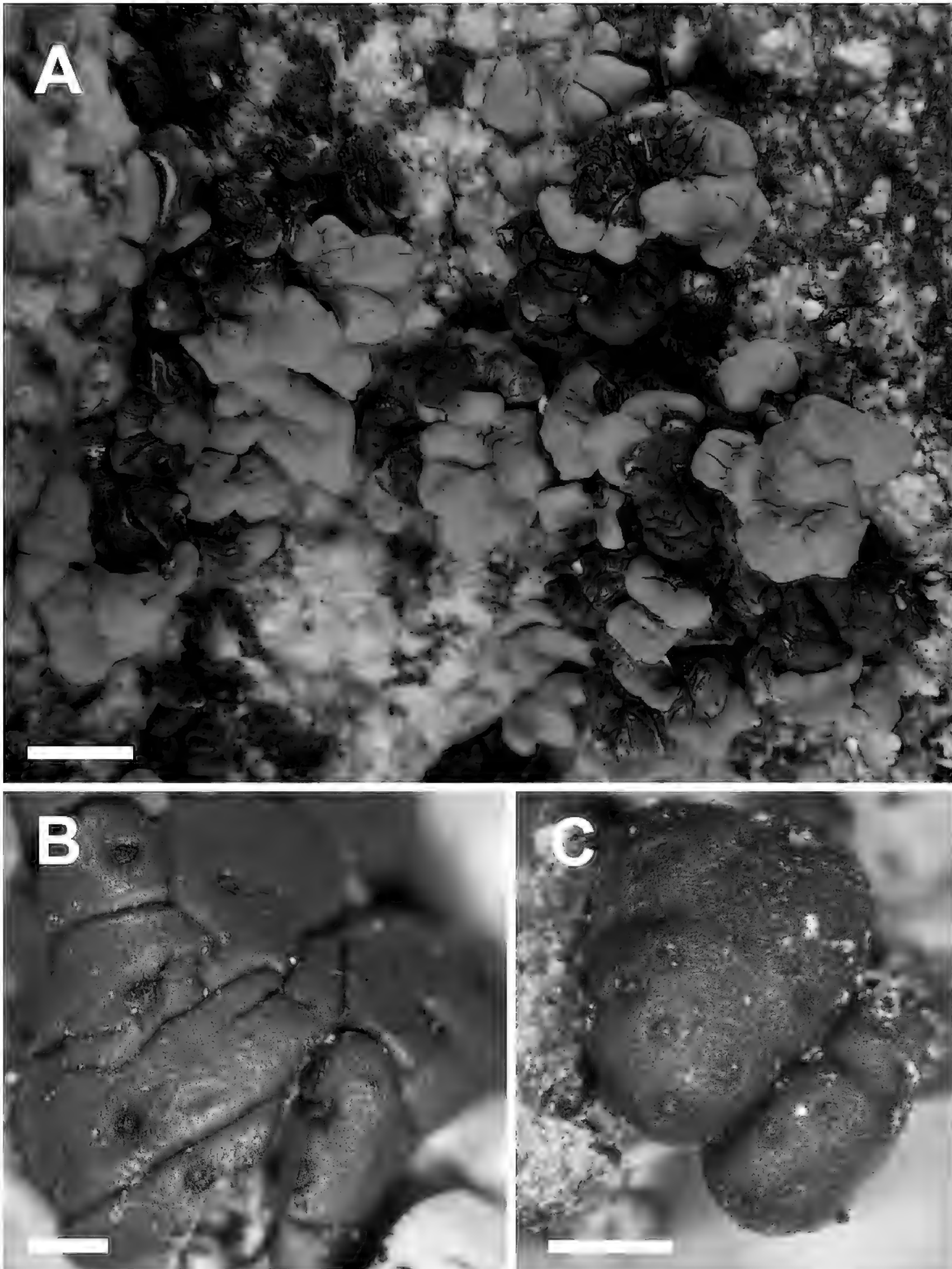
**FIGURES 1 AND 2.**

**DIAGNOSIS.** – Similar to *Heteroplacidium compactum*, but a juvenile parasite on *Acarospora socialis*, developing an independent lichenized brown thallus with filamentous medullary hyphae, longer conidia and larger ascospores.

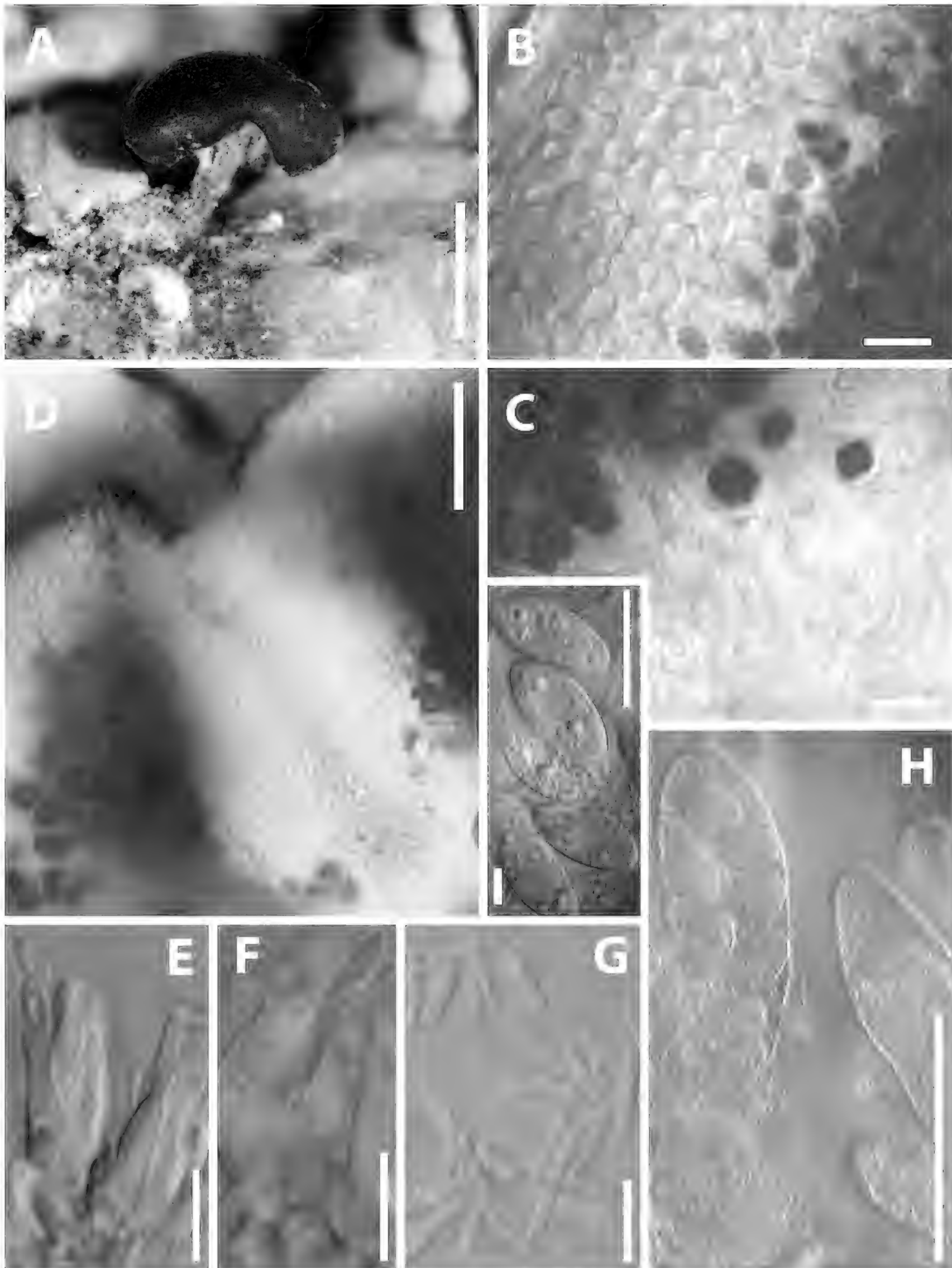
**TYPE: U.S.A. CALIFORNIA.** SAN DIEGO CO.: Anza Borrego Desert State Park, Yaqui Pass, 33°08'46"N, 116° 20'54"W, 1820 m., 23.xii.2005, K. Knudsen et al. 4811 (NY, holotype; UCR, isotype).

**DESCRIPTION.** – Endokapylic in *Acarospora socialis*; infection dark brown, vegetative hyphae not observed. *Thallus* independent or semi-independent, epilithic, squamulose, rarely areolate. *Squamules* usually convex, to 5 mm wide, dispersed or clustered, in association with *Acarospora socialis*, up to 0.5 mm thick, usually elevated by a pale stipe, rarely broadly attached by rhizohyphae. *Upper surface* dark brown, sometimes with remnant patches of yellow from the host, smooth to rugulose, with or without fissures. *Lower surface* pale or dark. *Upper cortex* 40–60 µm thick, paraplectenchymatous of round to angular cells, 5–9 µm in diam., lower layer hyaline, narrow upper layer reddish brown. *Epinecral layer* 10–20 µm thick. *Algal layer* with often jagged delimitation, up to 200 µm thick; algal cells mostly 10–15 µm wide. *Medulla* prosoplectenchymatous, up to 250 µm thick, sometimes obscured by large and small crystals only partially dissolving in nitric acid, hyaline thin-walled hyphae mostly 4–5 µm wide, vertically-oriented, often intricate, continuous with rhizohyphae. *Lower cortex* entirely lacking or of more densely packed hyphae with some round cells. *Rhizohyphae* 4.0–5.0 µm thick, thin-walled, hyaline. *Perithecia* globose, up to 500 µm in diam., with usually distinct collaret around ostiole, lacking an involucrellum, the exciple 40–50 µm thick, hyaline. *Asci* initially narrow and cylindrical, ca. 50–80 × 15 µm, becoming clavate and broader to 25 µm and usually shorter; *ascospores* biserial, hyaline, with immature ascospores

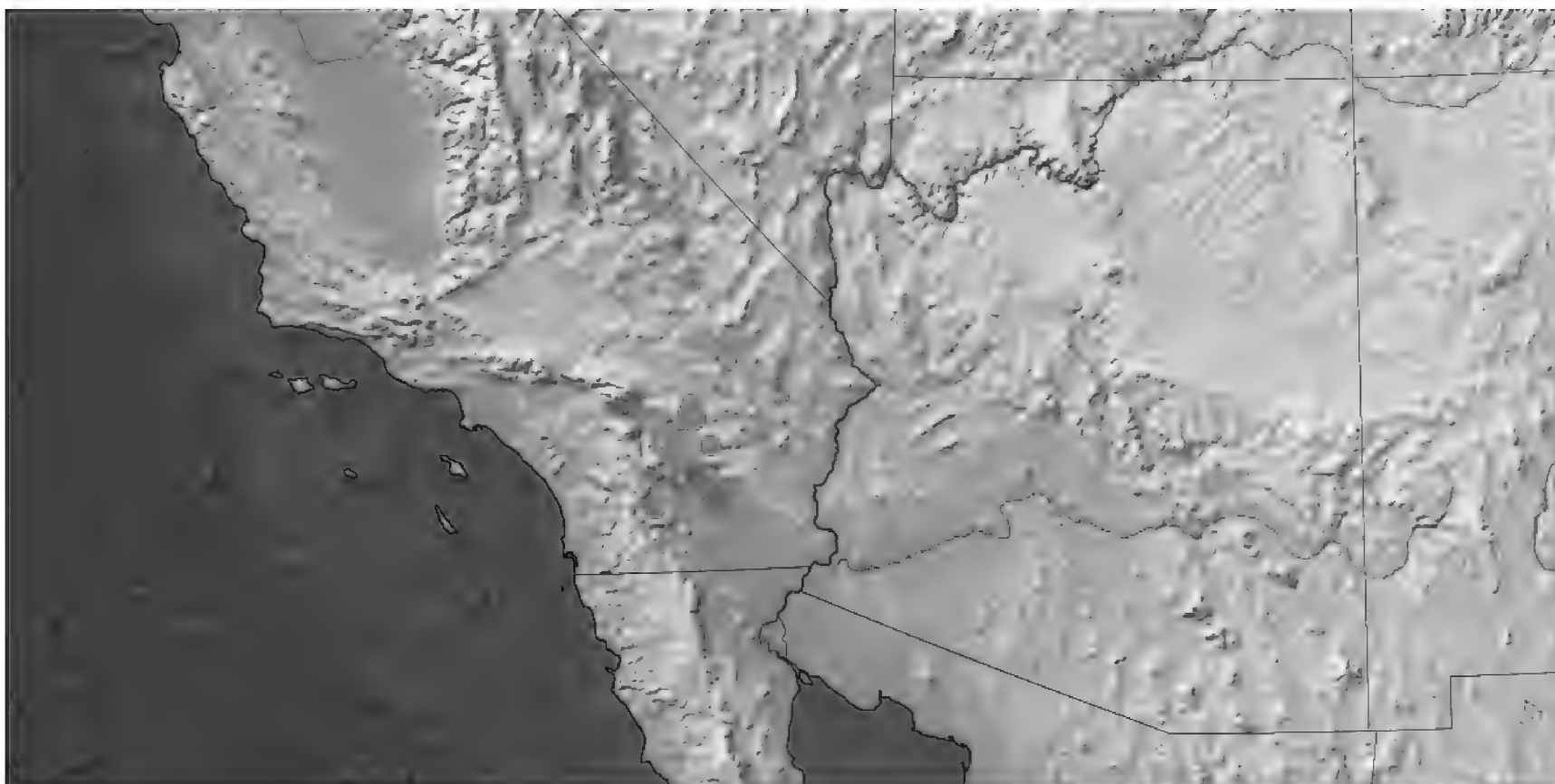




**Figure 1**, habit and external morphology *Heteroplacidium transmutans* (all from Kocourková 8250). A, habit. B, immersed perithecia with typical collaret. C, immersed pycnidia. Scales: 2.0 mm: A and B; 500  $\mu$ m: C.



**Figure 2**, anatomy and internal morphology of *Heteroplacidium transmutans* (all from Kocourková 8250). A, stipitate squamule. B, cortex with globose cells. C, prosoplectenchymatous medulla. D, vertical section of pycnidium. E, formation of conidia on ampulliform conidigenous cells. F, conidiogenesis, formation of transverse septum. G, simple conidia. H, nearly mature ascus with ascospores. I, mature ascospores. Scales: 1.0 mm: A; 50 µm: H; 20 µm: I; 10 µm: B and E-G. All preparations made in water.



**Figure 3**, geographic distribution of *Heteropladidium transmutans* based on specimens examined for this study.

initially globose, becoming broadly ellipsoid, and then elongated and narrower when mature  $(14.5-17.0-19.25-21.5(-22.5) \times (8.0-8.3-8.7-11.0(-12) \mu\text{m}$  ( $n=20$ ),  $l/b= (1.3-1.6-2.0-2.3(-2.6)$ . *Periphyses* furcate,  $20-35 \mu\text{m}$  long,  $2-4 \mu\text{m}$  in diam. *Pycnidia* laminal, *Dermatocarpon*-type, pyriform, mostly  $100-120 \mu\text{m}$  wide, conidigenous cells ampulliform  $12-20 \times 4.5-7.5 \mu\text{m}$ , conidia  $(9-10.5-12-13.5(-15) \times 1.5-2-2.5 \mu\text{m}$  ( $n=20$ ). Spot tests negative, lacking secondary metabolites.

ETYMOLOGY. – The specific epithet refers to the morphing of the lichenicolous lichen out of the thallus of the host.

DISTRIBUTION AND ECOLOGY. – The new species is known from southern California (figure 3), where it occurs in the Sonoran and Mojave Deserts. It is always either parasitic on *Acarospora socialis* or found growing independently on granite but closely associated with that species.

DISCUSSION. – The recognition of the new taxon as a member of the genus *Heteropladidium* is based on the mature squamulose thallus, *Dermatocarpon*-type pycnidia, the paraplectenchymatous cortex, and the clavate asci with biseriolate ascospores (Breuss 1996; Gueidan et al. 2009). Most *Heteropladidium* species are paraplectenchymatous throughout, thus having a paraplectenchymatous medulla, clearly distinct from the rhizohyphae, which often become brown-walled with age. However, *H. transmutans* has filamentous medullary hyphae with hyaline rhizohyphae. *Heteropladidium fuscum*, another parasitic species, also has a partly or largely filamentous medulla. The host of *H. transmutans*, *Acarospora socialis*, has filamentous medullary hyphae continuous with hyaline rhizohyphae. The comparison of medullary hyphae and algae in *Acarospora socialis* and *H. transmutans* revealed no noticeable morphological differences. Based on our morphological studies of the new species, during the development of an independent lichenized thallus, we hypothesize that *H. transmutans* absorbs the mycobiont of *A. socialis*, retaining its alga, as well as its filamentous medullary hyphae and hyaline rhizohyphae.

An important characteristic of *Heteropladidium transmutans* is that the squamules are formed by morphing out of the host squamules. A similar but somewhat different mode of development is known from *H. fuscum*, which is an obligate parasite on *Circinaria calcarea* (L.) A. Nordin. *Heteropladidium fuscum* starts its development with small brown thallus initials on the thallus of the host and eventually destroys the host (see Zehetleitner (1978) sub *Verrucaria insularis*). The small thallus initials grow to form islands on the host, little by little replacing the tissue of the host thallus with that of the parasite. The mature thallus of *H. fuscum* is free-living and occupies the space formerly covered by the host. Contrary



to the new species, *H. fuscum* also destroys the alga of the host; a different, suitable alga seems to be captured by the thallus initials, as it can be seen in the very early infectious stage.

In the deserts of southern California, *Heteropladidium transmutans* is at first glimpse indistinguishable from the common species *H. compactum*, which is regularly associated with the equally common *Acarospora socialis*. *Heteropladidium transmutans* differs from *H. compactum* especially in having a prosoplectenchymatous medulla rather than a paraplectenchymatous medulla. *Heteropladidium transmutans* also differs from *H. compactum* in having longer conidia ( $9-15 \times 1.5-2.5$  vs.  $5-7 \times \sim 1.5$   $\mu\text{m}$ ). The ascospores of *H. transmutans* are generally longer than those of *H. compactum* ( $14-22 \times 8-12$  vs.  $13-16 \times 8-10$   $\mu\text{m}$ ). Note that the size of the conidia and ascospores of *H. compactum* reported here are based on Breuss (2007). In early ontogeny, the spores of *H. transmutans* are globose to broadly ellipsoid, only becoming more narrowly ellipsoid when fully mature, and they can be confused with the usually broadly ellipsoid mature ascospores of *H. compactum*. In an effort to aid in the identification of additional specimens of *H. transmutans* we have included a key to *Heteropladidium* in North America at the end of this section.

*Placidium acarosporoides* (Zahlbr.) Breuss is also common throughout the deserts of southern California, often growing on rock with *Heteropladidium compactum* and *Acarospora socialis*. It is superficially similar to *H. transmutans*, but the thallus usually is darker brown in coloration in the field. *Heteropladidium transmutans* differs from *P. acarosporoides* mainly in the longer conidia ( $9-15 \times 1.5-2.5$  vs.  $3-6 \times 1$   $\mu\text{m}$ ), longer mature spores ( $14-22 \times 8-12$  vs.  $13-17 \times 8-11$   $\mu\text{m}$ ), as well as the parasitic habit.

Based on more than one hundred days of field work in Joshua Tree National Park (Knudsen et al. 2013b), we found *Heteropladidium transmutans* to be relatively rare. This is surprising considering that its host, *Acarospora socialis*, is one of the most common lichens in southern California deserts. We saw no evidence of *H. transmutans* occurring on any other host. In the habitats where *H. transmutans* occurs in national and state reserves, it appears unthreatened at this time. Future intensive field studies may prove the new species to be widespread if it occurs throughout the range of *A. socialis* in southwestern North America (Knudsen 2007).

In the checklist of the lichenicolous fungi of California, *Heteropladidium transmutans* was reported as *H. compactum* and the holotype was illustrated by a color plate (Kocourková et al. 2012). *Heteropladidium compactum* will be replaced by *H. transmutans* in the updated checklist of lichenicolous fungi for the region, because we have observed no evidence that *H. compactum* is parasitic in California. McCarthy (2001) has observed the same lack of parasitism in Australia. According to Breuss (1994), *H. compactum* is facultatively lichenicolous in Europe, although it is also possible that the European concept of the name is heterogeneous, and any parasitic specimens deserve careful study (Prieto et al. 2010b). The life cycle of individual lichenicolous lichens, such as *H. transmutans* and *H. fuscum*, and the expropriation or replacement of the algal and fungal components of the host is a fascinating area for future studies.

*Specimens examined (all on Acarospora socialis).* – **U.S.A. CALIFORNIA. RIVERSIDE CO.:** Joshua Tree National Park, Cottonwood Mountains, Cottonwood Canyon,  $33^{\circ}43'09.3''\text{N}$ ,  $115^{\circ}48'30.4''\text{W}$ , 887 m., 8.xii.2011, K. Knudsen 14451.1 & M. Michalová (LI, UCR), K. Knudsen 14451.2 & M. Michalová (JOS); W edge of Hexie Mts., Squaw Tank,  $33^{\circ}55'45.17''\text{N}$ ,  $116^{\circ}4'29.31''\text{W}$ , monzogranite area with *Larrea tridentata*, *Ferocactus cylindraceus*, and *Yucca brevifolia*, on base of monzogranite tor, 1138 m., 10.vii.2013, J. Kocourková 8369 & K. Knudsen (hb. Kocourková and Knudsen); between Hexie and Pinto Mts., near Pinto Basin Rd.,  $35^{\circ}56'46.77''\text{N}$ ,  $115^{\circ}58'36.52''\text{W}$ , 887 m., N-facing wall of crest in small wash near road, on granite, 8.x.2012, J. Kocourková 8250 & K. Knudsen (hb. Kocourková and Knudsen, LI). **SAN BERNARDINO CO.:** 1 km S of north entrance, crest of hills among wash, near the road on N-facing wall of a hill,  $34^{\circ}4'12.37''\text{N}$ ,  $116^{\circ}1'57.77''\text{W}$ , 876 m., on granite, 13.xi.2012, J. Kocourková 8368 & K. Knudsen (hb. Kocourková and Knudsen; LI [2 specimens]); Indian Cove, north-facing slope of Wonderland of Rocks,  $34^{\circ}0'1.93''\text{N}$ ,  $116^{\circ}3'35.36''\text{W}$ , on low monzogranite outcrop among high tors, 961 m., 13.vii.2013, J. Kocourková 8371 & K. Knudsen (hb. Kocourková & Knudsen, LI).

## Key for *Heteropladidium* in North America

1. Terricolous, with thick-walled rhizohyphae (>0.5 µm) ..... *H. congestum* (Breuss & McCune 1994 as *Catapyrenium*; McCune & Rosentreter 2007)
1. Lichenicolous or saxicolous, with thin-walled rhizohyphae ..... 2
  2. Parasitic on *Acarospora socialis*, with a prosoplectenchymatous medulla ..... *H. transmutans*
  2. Not parasitic on *Acarospora socialis*, with a paraplectenchymatous medulla ..... 3
    3. Parasitic on *Staurothele*, on calcareous rock ..... *H. zamenhofianum* (Breuss 2007 as *Verrucaria*)
    3. Not parasitic on *Staurothele*, on calcareous and non-calcareous rock ..... *H. compactum* (Breuss 2007 as *Verrucaria*)

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We thank our reviewers, Patrick McCarthy (Australia) and an additional anonymous reviewer. We thank the curator of NYBG for the loan of the holotype. Kerry Knudsen was funded in part by a co-operative agreement between the University of California at Riverside and Joshua Tree National Park. We thank Jim Dice of Anza Borrego Desert State Park and Kevin Fleming of California Department of Parks and Recreation for supplying us with collection permits. The work of Jana Kocourková was supported financially by the KONTAKT II Program of International Cooperation in Research and Development for scientific cooperation between the Czech Republic and USA, LH 11057 from Ministry of Education, Youth and Sports.

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## Notes on new and interesting cyanolichens from Ontario, Canada

CHRISTOPHER J. LEWIS<sup>1</sup>

**ABSTRACT.** – *Pterygiopsis neglecta*, formerly only known from the area of type locality, along the River Elbe in Hamburg, Germany, is reported here for the first time in North America. *Placynthium stenophyllum* var. *stenophyllum* is a new record for Canada, and *Cryptothele granuliformis* and *Placynthium stenophyllum* var. *isidiatum* are new to Ontario. Notes on *Ephebe lanata*, *Lichinella nigritella*, *Placynthium asperellum*, *Psorula rufonigra*, *Pyrenopsis polycocca*, *Spilonema revertens*, *Synalissa symphorea*, and *Thermutis velutina*, which may all be overlooked and under collected in Canada, are also presented.

**KEYWORDS.** – Rare lichens, Lichinaceae, Placynthiaceae, Appalachian-Great Lakes, Northeastern North America.

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### INTRODUCTION

During recent field work in the Canadian Province of Ontario, several interesting rare or otherwise noteworthy cyanolichen species were discovered. The present contribution documents these discoveries, providing discussion and illustrations intended to supplement the checklist of Ontario lichens that is currently being compiled (Newmaster et al., in press). The notes presented here include a new report for North America, a new report for Canada, two new reports for Ontario, and a number of noteworthy collections of species that are often considered rare. With these additions the number of lichen species known from Ontario is now 1075.

### MATERIALS AND METHODS

Specimens were identified with a compound or stereo microscope and chemical spot tests using para-phenylenediamine dissolved in ethyl alcohol (PD), sodium hypochlorite (C), 10% potassium hydroxide (K), and Lugol's iodine (I) (Brodo et al. 2001). In situ images were captured with a Sony Alpha 100 digital SLR camera mounted with a 100 mm 2.8f macro lens. Microscopic photos were captured using a Zeiss compound and dissecting microscope mounted with an Infinity 2-2 CCD digital camera and Infinity Capture 5.0.2 software. Image sharpness and size were very slightly augmented for publication with Adobe Photoshop. Range maps were created using ESRI ArcMap 9.3.1 with herbarium data downloaded from the Consortium of North American Lichen Herbaria (CNALH) and personal observation points. To validate the claims of these species being new to their respective regions, specimens were examined at the New York Botanical Garden (NY) and the Canadian Museum of Nature (CANL). Other relevant literature, herbarium materials and herbarium staff were also contacted. All specimens are deposited in the Canadian Museum of Nature (CANL), Herbarium Hamburgense (HBG), or New York Botanical Garden (NY) as indicated in the text.

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## NEW AND INTERESTING REPORTS

The notes presented below are arranged alphabetically by genus and species. Names preceded by an asterisk “\*” are newly reported for Ontario, those preceded by two asterisks “\*\*” are newly reported for Canada, and the species preceded by three asterisks “\*\*\*” is new to North America. Nomenclature follows the 18<sup>th</sup> edition of the North American Lichen Checklist (Esslinger 2012). Taxonomic authorities follow Brummitt and Powell (1996).

### \**Cryptothele granuliformis* (Nyl.) Henssen

FIGURE 1A.

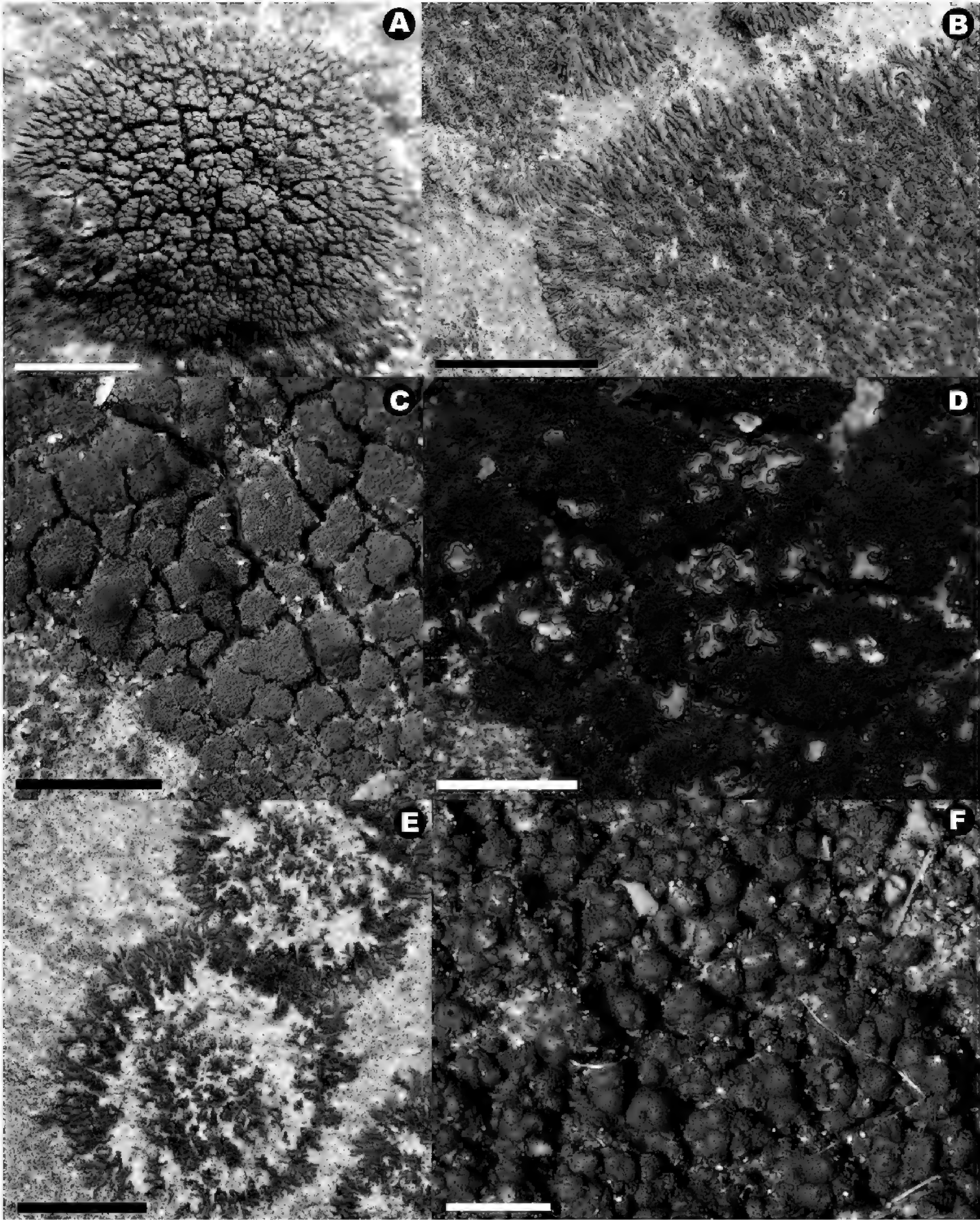
NOTES. – *Cryptothele granuliformis* was first collected in Ontario in Algonquin Park in 2010 (Lewis et al. in prep.). Species of *Cryptothele* are superficially similar to members of the genus *Pyrenopsis* in having more or less perithecioid apothecia with periphysoids, a highly gelatinous hymenium, with only sparse and gracile paraphyses, and usually slender asci often with pointed tips (Jørgensen 2007, Schultz 2006a). With the exception of a single historical record from the Northwest Territories (Thomson 1997), the specimens cited below are the only occurrences of this species known from Canada. It is also known from Scandinavia and Finland, where it is widespread and locally common (Jørgensen 2007), and Greenland (Thomson 1997). The species differs from the only other *Cryptothele* species known from North America, *C. permiscens* (Nyl.) Hellb., by forming lobes or having an effigurate thalline margin (vs. an indistinct margin) and having smaller ascospores (6–8 x 4–5 µm vs. 8–10 x 3–4 µm) (Jørgensen 2007). The ascospores in the material cited below were modestly larger than those reported in the literature (8–10 x 4–5 µm), but match well the type collection in all other respects (M. Schultz, pers. comm.).

*Specimens Examined.* – **CANADA. ONTARIO.** NIPPISSING DISTRICT: Algonquin Provincial Park, Barron Canyon, 6.v.2010, on shaded granite cliff face with nutrient enrichment along the Barron River, *C.J. Lewis 413* (CANL; det. M. Schultz). KENORA DISTRICT: Precambrian bedrock outcrops - N, ca. 65 km S of the Hudson Bay coast, ca. 83 km ESE of Peawanuck on Winisk River, bedrock outcrop, 6.vii.2010, on open Precambrian granitic rocky summit, *M.J. Oldham 378301* (CANL). COCHRANE DISTRICT: Escarpment Transition Area of Natural and Scientific Interest (ANSI), 51 km SW of southern end of James Bay (mouth of Harricanaw River), 56 km SE of Moosonee, alternating fen rock outcrop complex, 12.vii.2012, on granite subject to runoff, *C.J. Lewis 1303* (CANL).

### *Ephebe lanata* (L.) Vain.

NOTES. – When Wong and Brodo (1990) reported *E. lanata* from the province they suggested that it has probably been overlooked and likely more common than was known at that time. The range extension into northern Ontario supports this claim, and the lichen will likely be found in intervening areas with appropriate habitat. *Ephebe lanata* has few or no spine-like side branches and is restricted to moist rocks (i.e., lake and river shore spray zones), whereas *E. hispidula* (Ach.) Horw. and *E. perspinulosa* Nyl. bear numerous short, spine-like side branches and are more subfruticose (Jørgensen 2007). *Ephebe hispidula* is also typically found on boulders in woodlands and other inland localities (Jørgensen 2007). In addition, *E. hispidula* has asci with 16 ascospores whereas those *E. lanata* contain only eight ascospores (Goward 1999, Jørgensen 2007). *Ephebe hispidula* is not known from Ontario, but is discussed here because of its similarity to *E. lanata*. *Ephebe solida* Bornet is another species that could be confused with *E. lanata*, although like *E. hispidula* it is not presently known from Ontario. *Ephebe lanata* differs from *E. solida* by the lack of tapering tips and whorled and dichotomously branching at the terminus of the branches, and thicker filaments (130–260 µm in *E. solida* vs. 70–140 µm in *E. lanata*) (Goward 1999, Hinds & Hinds 2007).

*Specimen Examined.* – **CANADA. ONTARIO.** KENORA DISTRICT: Jobes Creek ANSI, 270 km N of Lake Superior, rapids and rocky outcrops along stream, 19.vii.2013, on granitic rocks flushed with seasonal sheeting flows, *C.J. Lewis 1691* (CANL).



**Figure 1**, selected species of Lichinaceae discussed here. A, *Cryptothele granuliformis* (Lewis 1303, *in situ*). B, *Placynthium stenophyllum* var. *stenophyllum* (Lewis 1440). C, *Placynthium asperellum*, (Lewis 1439). D, squamules of *Psorula rufonigra* growing on cushions of *Spilonema revertans* (Lewis 1763). E, *Placynthium stenophyllum* var. *isidiatum* (Lewis 1344). F, *Synalissa symphorea* (Lewis 1596). Scales = 5.0 mm in B & C, 4.0 cm in E & F, 2.0 cm in A, 1.0 cm in D.

***Lichinella nigritella* (Lettau) P.P. Moreno & Egea**

NOTES. – *Lichinella nigritella* has only been reported from a few scattered locations in Ontario. It grows over calcium rich rock and can be confused with *Thyrea confusa* Henssen, but that taxon lacks thick ligulate, rugulose, thickened, and shiny lobe margins. It is also possible to confuse *L. nigritella* with members of *Collema*. The two are most easily distinguished by photobionts; *Nostoc* in *Collema* and a member of *Chroococcales* (most often *Gloeocapsa*) in *Lichinella* (Goward 1999, Hinds & Hinds 2007, Jørgensen 2007).

*Specimen Examined.* – **CANADA. ONTARIO.** KENORA DISTRICT: Lake of the Woods, Gull Island, on calcareous rock close to the shoreline, 10.vi.2013, *C.J. Lewis 1579* (CANL).

***Placynthium asperellum* (Ach.) Trevis.**

**FIGURE 1C.**

NOTES. – Historical records of *Placynthium asperellum* in Ontario are known from calcareous rocks along the northern Lake Superior shoreline (Henssen 1963, CNALH 2013). The collections reported here were also found in similar habitats on the shorelines of Lake Erie (southern Ontario) and Shoal Lake (northwestern Ontario; west of Lake of the Woods). These reports extend the distribution of *P. asperellum* to the far western and far southern parts of Ontario. *Placynthium asperellum* was not found in similar habitats on the Bruce Peninsula when large expanses of calcareous shoreline rocks were examined along both the Georgian Bay and Lake Huron (Brodo et al. 2013).

*Specimen Examineds.* – **CANADA. ONTARIO.** WELLAND CO.: Morgan's Point Conservation Area, shelf limestone, Lake Erie shoreline, 4.iv.2013, on upland limestone, *C.J. Lewis 1439* (CANL). KENORA DISTRICT: Lake of the Woods, Cliff Island, 10.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1579* (CANL).

**\**Placynthium stenophyllum* var. *isidiatum* Henssen**

**FIGURE 1E.**

NOTES. – This is the first report of *Placynthium stenophyllum* var. *isidiatum* from Ontario and the easternmost report from North America to date. In Canada it has previously been reported from British Columbia (Henssen 1963) where it is provincially ranked as S3 or “vulnerable” by the British Columbia Conservation Data Center (2013). It is also known from scattered locations in the midwestern United States (Henssen 1963). The Ontario population was found growing on calcareous rock in a karst formation in the Hudson Bay Lowlands Region along the Attawapiskat River. The taxon differs from all other species of *Placynthium* known from Ontario by the lack of a black hypothallus and loosely attached isidiate thallus. It differs from *P. stenophyllum* var. *stenophyllum* by its loosely attached thallus and smaller isidiate lobes (Henssen 1963).

*Specimen Examined.* – **CANADA. ONTARIO.** COCHRANE DISTRICT: Attawapiskat Karst ANSI, 64 km W of Attawapiskat Airport along the Attawapiskat River, limestone cliffs and moss covered boulders under mixed forest on an island, 13.vii.2012, on a shaded calcareous cliff, *C.J. Lewis 1344* (CANL).

**\*\**Placynthium stenophyllum* (Tuck.) Fink var. *stenophyllum***

**FIGURES 1B AND 3A (MAP).**

NOTES. – This taxon occurs throughout the central and eastern continental United States, and was previously thought to reach its northern limit close to the Canadian border (Henssen 1963: fig. 66) (Figure 3 herein). This new report from the northern shoreline of Lake Erie, where it was found growing abundantly, now extends its range into Canada. *Placynthium stenophyllum* var. *stenophyllum* differs from all other Ontario *Placynthium* species by its thalloid margin surrounding the apothecia and filiform lobes with a colorless or pale undersurface (Henssen 1963). The differences between the two varieties of *P. stenophyllum* are discussed under *P. stenophyllum* var. *isidatum* above. *P. stenophyllum* var. *stenophyllum*



can be found growing intermingled with *P. petersii* (Nyl.) Burnham, which is distinguished by its flatter lobes and dark lower surface (Henssen 1963).

*Specimen Examined.* – **CANADA. ONTARIO.** WELLAND CO.: Morgan's Point Conservation Area, shelf limestone Lake Erie shoreline, 4.iv.2013, on upland limestone, *C.J. Lewis 1440* (CANL).

### ***Pyrenopsis polycocca* (Nyl.) Tuck**

NOTES. – *Pyrenopsis* is a poorly understood genus, probably because of the lack of mature, fruiting material available for examination. Therefore, identification of most North American material is questionable (Jørgensen 2007, Brodo et al. 2001). The material cited here, however, does have a well-developed thallus and apothecia, and agrees with descriptions in the literature reviewed (Brodo et al. 2001, Fink 1935, Ryan unpublished), as well as with reference specimens in CANL. *Pyrenopsis polycocca* has a blackish (reddish when wet) granulose thallus with a chroococcoid (*Gloeocapsa*) photobiont, numerous adnate, globose, open, and deeply concave apothecia. It was found growing over wet granite along a sheeting/seepage track of the adjacent creek where, in times of seasonal higher flows, it undoubtedly becomes inundated. It has a scattered distribution in Ontario and in the greater Appalachian-Great Lakes region (Brodo et al. 2001).

*Specimen Examined.* – **CANADA. ONTARIO.** PETERBOROUGH CO.: along Eels Creek, North of Northeys Bay Road, north of Stoney Lake and just west of Petroglyphs Provincial Park, 20.iv.2013, on granite rock in seepage area adjacent to river rapids, *C.J. Lewis 1452* (CANL).

### ***Psorula rufonigra* (Tuck.) Gotth. Schneid.**

**FIGURES 1D AND 3B (MAP).**

NOTES. – *Psorula rufonigra* is always found growing on the cyanolichen *Spilonema revertens* Nyl. (Brodo et al. 2001, Thomson 1997). It grows on calcareous or non-calcareous rock with calcareous influence, inclined moist surfaces, but has also been found on wet calcareous soils (Thomson 1997). The two species were found growing together several times in the same general area of northwestern Ontario along the northern shoreline of Lake Superior with one of the Albany River occurrences extending the Ontario range of *P. rufonigra* inland and to the north by several hundred kilometers (Figure 4).

*Specimen Examined.* – **CANADA. ONTARIO.** KENORA DISTRICT: Lake of the Woods, Cliff Island, 10.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1566* (CANL). RAINY RIVER DISTRICT: Rainy Lake, 12.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1614* (CANL). Albany River, 200 km north of Lake Superior, 21.vii.2013, on calcareous rock close to the shoreline, large rapids with vertical rock faces, *C.J. Lewis 1763* (CANL).

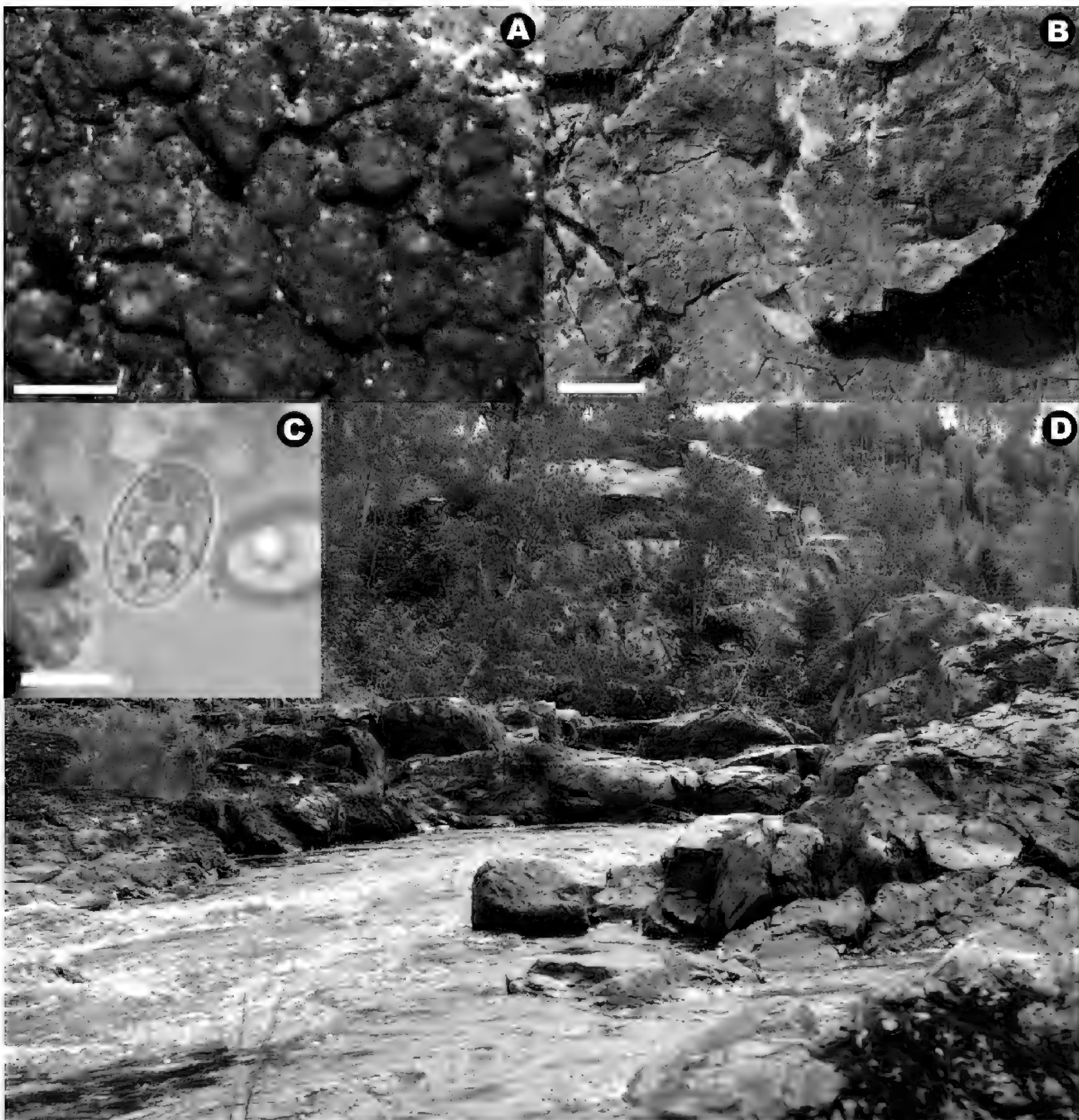
### **\*\*\*“*Pterygiopsis*” *neglecta* (Erichsen) M. Schultz & Thüs comb ined.**

**FIGURE 2.**

NOTES. – The genus *Pterygiopsis* was described in 1890 by Vainio for a single species (*P. atra* Vain.) from Brazil that was found growing on wet rocks near the ocean (Jørgensen 1990). Since then, confusion within the genus has resulted in species originally described as *Pterygiopsis* being reexamined and recombined in other genera, whereas others, originally described in other genera, have been placed within *Pterygiopsis* after more reliable material has become available (Henssen & Jørgensen 1990, Schultz 2006b, Jørgensen 2007). A lack of adequate material has resulted in the uncertain delimitation of this genus (Jørgensen 2007) and it appears that much work is needed to clarify the generic boundaries within the group (Schultz, pers. comm.).

As originally circumscribed (Vainio 1890), *Pterygiopsis* is a cyanolichen, with a chroococcoid photobiont, thick walled, 8-spored asci, and simple ascospores (Figure 1C) (Gilbert and Purvis 2009). Some members of this genus lack apical amyloid structures in the asci and have a hymenium that becomes divided by intrusions of sterile hyphae (Schultz 2006b). This a common feature of *Pterygiopsis*, but it also occurs among the genera of the *Lichinaceae* (Schultz 2006b). Species of *Pterygiopsis* are typically found in irrigation zones or margins of water bodies (creeks, rivers, lakes, oceans), but they also grow on a variety of rocks (sandstone, granite, and calcareous rocks) on moist shaded north or northeast facing slopes and cliffs with frequent seepage (Jørgensen 2007, Schultz 2006b).





**Figure 2, *Pterygiopsis neglecta*.** A, habit (Lewis 1802). B, habit of specimen *in situ*. C, ascospores (Lewis 1802). D, habitat of the species where it was found in Ontario.

The type specimen of *Pterygiopsis neglecta* was collected in 1904 on the shores of the Elbe River near Hamburg, Germany (Erichsen 1940). Its identity remained a mystery until it was described by Erichsen (1940) as *Forssellia neglecta* Erichsen. Further work is still needed to clarify its taxonomy, but Thüs and Schultz (2009) suggested that *Forssellia neglecta* was a “forgotten taxon” and proposed to combine the epithet into *Pterygiopsis*. The authors were hesitant to formally make the combination because of severe problems with the generic delimitation of the genus *Pterygiopsis* (Schultz, pers. comm.). Therefore, it remains unpublished, but it is listed on the checklist of lichens and lichenicolous fungi in Germany (Wirth et al. 2010) as *P. neglecta*.

In Europe (Germany) *Pterygiopsis neglecta* was found growing on boulders (granite, limestone, concrete etc.) in the fresh water tidal zone along the bank of the river Elbe. These areas experience regular inundation for approximately one to three hours during high tide (Thüs & Schultz 2009). Associated species in Europe include *Staurothele frustulenta* Vain., *Caloplaca isidiigera* Vězda, *C. subpallida* H. Magn., *C. arenaria* (Pers.) Müll. Arg. (Thüs & Schultz 2009). In North America, *P. neglecta* was found

growing below the seasonal high water line in a slack or sheltered backwater area out of the thalweg, in a river with 1–2 m seasonally high flows. The presence of a definite high water line and lack of other upland saxicolous epiphytes suggests that high waters persist well into the spring and perhaps return in the fall (Figure 1D). At the Ontario locality the taxon was found growing with other aquatic or amphibious lichen species such as *Dermatocarpon luridum* (With.) J.R. Laundon, *Ephebe* spp., and *Staurothele* spp. (Figure 1B). Due to its size, colour, and cryptic nature, it is undoubtedly overlooked. *Pterygiopsis neglecta* is expected to be found in similar fresh water habitats of lakes and rivers and also possibly on suitable substrata of inland dikes.

Three other species of *Pterygiopsis* have previously been reported from North America: *P. atra* Vaino, *P. canariensis* Henssen and *P. cava* M. Schultz (Esslinger 2012, Schultz 2006b). All of these species are allopatric with *P. neglecta* and appear to be restricted to southwestern North America (Schultz 2006b).

*Specimen Examined.* – **CANADA. ONTARIO.** TIMMINS DISTRICT: Kap-Kig-Iwan Provincial Park, Englehart River, South of Englehart, Ontario, 8.vii.2012, on inundated rock surface below high water line above falls, *C.J. Lewis 1199* (CANL, HBG; det. Schultz), 24.vii.2012, *C.J. Lewis 1802* (NY).

***Spilonema revertens* Nyl.**

**FIGURES 1D.**

NOTES. – This filamentous cyanolichen is rarely reported from Ontario. It was found growing with *Psorula rufonigra* (see discussion of that species above). It resembles *Thermutis velutina* (Ach.) Flot. but that species contains *Scytonema* as the photobiont, is much more weakly lichenized, and can be fertile (Jørgensen 2007). Fertile material of *Spilonema revertens* is presently unknown.

*Specimen Examined (growing with Psorula rufonigra).* – **CANADA. ONTARIO.** KENORA DISTRICT: Lake of the Woods, Cliff Island, 10.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1566* (CANL). RAINY RIVER DISTRICT: Rainy Lake, 12.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1614* (CANL); Albany River, 200 km N of Lake Superior, 21.vii.2013, on calcareous rock close to the shoreline, large rapids with vertical rock faces, *C.J. Lewis 1763* (CANL).

***Synalissa symphorea* (Ach.) Nyl.**

**FIGURES 1F AND 3C (MAP).**

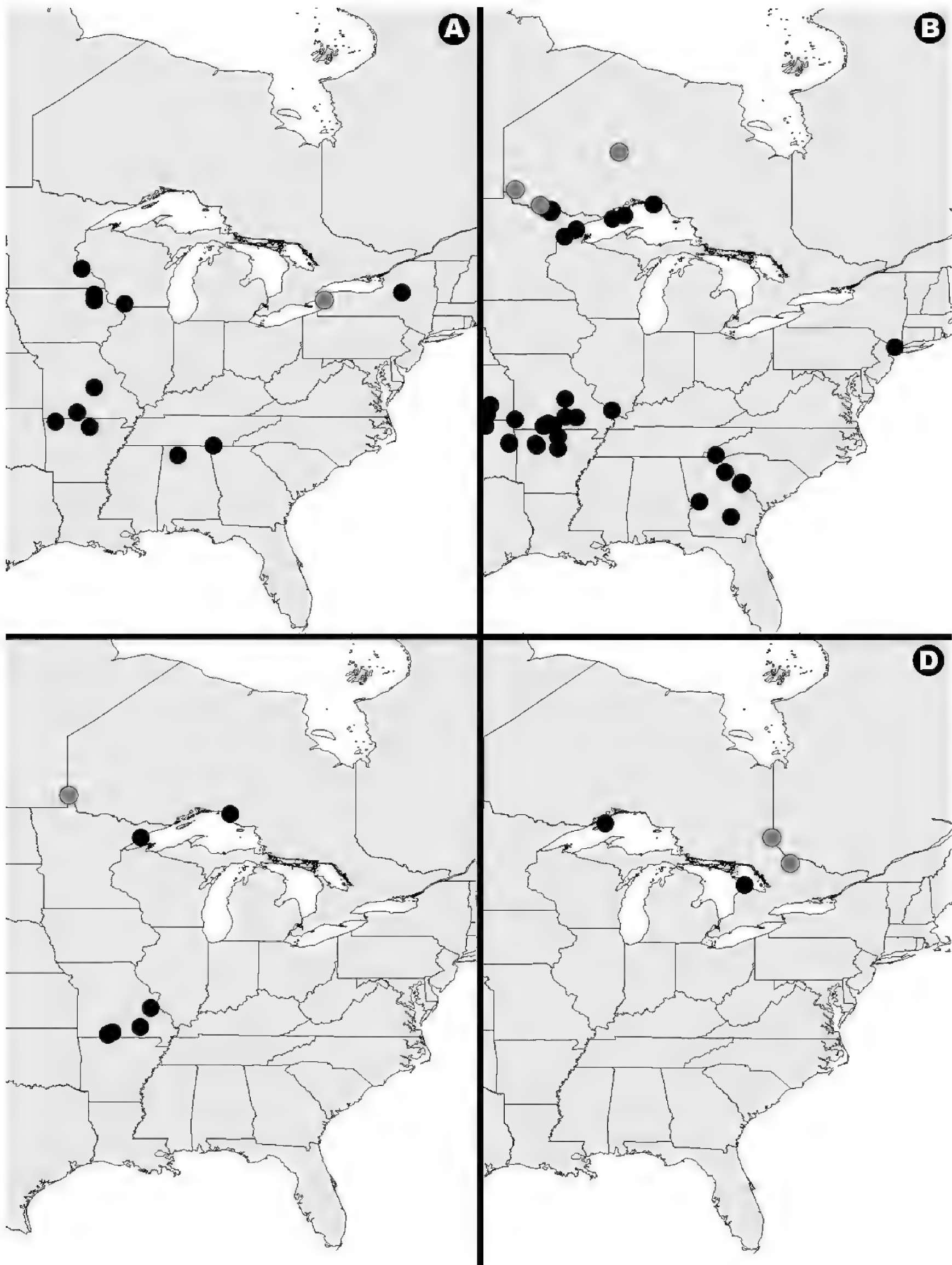
NOTES. – This is the second record of this species for Canada. The first is a collection made near Marathon, Ontario, on the north shore of Lake Superior in Heron Bay by Ainio Henssen (Crowe 1994) (Figure 5). Another North American species of *Synalissa*, *S. matogrossensis* (Malme) Henssen, is limited to the southwest (Schultz 2002). *Synalissa symphorea* differs from *S. matogrossensis* by having larger, thicker, club-shaped lobes (vs. tiny branched lobes) and polysporous (vs. 8-spored asci) (Schultz 2002).

*Specimen Examined.* – **CANADA. ONTARIO.** KENORA DISTRICT: Shoal Lake, 11.vi.2013, on calcareous rock close to the shoreline, *C.J. Lewis 1596* (CANL).

***Thermutis velutina* (Ach.) Flot.**

**FIGURE 3D (MAP).**

NOTES. – *Thermutis velutina* was first reported from Ontario by Wong and Brodo (1990) based on sterile material from the Cape Coker First Nations Reserve on the Bruce Peninsula (*Wong 2001*, CANL). No collections of this species have been made since then in Ontario or Canada. This is surprising considering the recent surge in interest in Ontario lichens, including a detailed inventory of Bruce Peninsula National Park and Fathom Five National Marine Park, only a short distance from the original collection site (Brodo et al. 2013). This species is also known from Quebec and British Columbia (Wong & Brodo 1990, Goward 1999) on the basis of collections made prior to the original report in 1990. A few scattered unverified records are shown from the United States (Arizona, Michigan and Washington) in CNALH (2013) (Figure 6). The specimens cited here are the first published records of fertile material in Canada. In both cases the lichen was found growing on shaded cliff faces with calcareous influence. *Thermutis velutina* is only weakly lichenized; if found without apothecia, it is often difficult to distinguish from unlichenized colonies of the cyanobacterium genus *Scytonema* (Goward 1999, Jørgensen 2007).



**Figure 3**, geographic distributions of *Placynthium stenophyllum* var. *stenophyllum* (A), *Psorula rufonigra* (B), *Synalissa symphorea* (C) and *Thermutis velutina* (D) in eastern North America. Black dots correspond to locations of vouchers available in the Consortium of North American Lichen Herbaria (CNALH), in most cases the identity of vouchers was not confirmed by the author for this study. Yellow dots correspond to the new occurrences discussed herein.

*Specimen Examined.* – **CANADA. ONTARIO.** NIPPISING DISTRICT: South of Haileybury, Devils Rock/Peak, along the western lake shore of Lake Temiskaming, 7.vii.2012, along a talus slope, *C.J. Lewis 1193* (CANL). NIPPISING DISTRICT: Algonquin Provincial Park, on the eastern shore of Carl Wilson Lake, shaded northwest facing cliff, granite with a calcareous influence, surrounded by mixed woods dominated by *Thuja occidentalis*, 31.vii.2011, *C.J. Lewis 644, 645, 646* (CANL).

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# New records of lichenicolous fungi and lichenicolous lichens from the Iberian Peninsula, with the description of four new species and one new genus

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**ABSTRACT.** – 110 records of lichenicolous fungi are reported from Andorra, Portugal and Spain, (mostly the latter country). One genus and four species are described as new to science: *Phaeospora everniae* on *Evernia prunastri*, *Polycoccum ibericum* on *Rinodina* sp., *Zwackhiomacromyces constrictocarpus* gen. et. sp. nov. on *Megalospora*, and *Zwackhiomyces melanohaleae* on *Melanohalea exasperata*. *Pronectria septemseptata*, is combined into the genus *Xenonectriella* as *X. septemseptata* (Etayo) Etayo & van den Boom. *Lichenostigma canariense* and *Sarcopyrenia bacillosa* are newly reported for Europe. Further new records for mainland Spain are *Neolamya peltigerae*, *Niesslia cladoniicola*, *Obryzum corniculatum*, *Phacopsis fusca*, *Phoma grumantiana*, *Polycoccum umbilicariae*, *Sclerococcum leuckertii*, *Sphaerellothecium atryneae*, *Stigmidium cerinae*, *S. ramalinae* and *Taeniolella beschiana*. A second world record of *Pronectria casaresii* is reported from northern Spain. The known distributions of many species are extended and discussed.

**KEYWORDS.** – lichens, taxonomy, biodiversity

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## INTRODUCTION

Many readers will be surprised to learn that there is not a published checklist of the lichenicolous fungi from the Iberian Peninsula, although a seminal contribution would certainly be Santesson (1960). A little more than forty years later after Santesson's work, Llimona and Hladun (2001) summarized the lichenized and lichenicolous fungus biota of the Iberian Peninsula, reporting 2426 lichens and 368 lichenicolous fungi. This first comprehensive accounting of the Iberian lichen and lichenicolous biota covered not only mainland Spain, but also the Balearic Islands and Portugal. However, it did not extend to the Canary Islands, Madeira or the Azores, well known for their impressive lichen flora (Hafellner 1995, 1999, 2002, 2005, 2008). When Llimona and Hladun published their checklist they planned it as a guide to bibliographic sources for the preparation of the "Flora Liquenológica Ibérica" that would be updated subsequently on-line. Although this resource was successively updated (Hladun & Llimona 2002-2007), it eventually fell dormant and has not been updated in recent years.

Although we have not maintained a count of the new species and reports for the region during this period (2001-2014), we estimate that more than 400 lichenicolous taxa have been reported to date, many of them newly described from Spain. Particularly substantial contributions have been published by Atienza et al. (2003), Calatayud and Triebel (2003), Calatayud et al. (2002), Etayo (2002, 2008, 2010, 2010b) and Navarro-Rosinés and Roux (1995). Great Britain is among the countries with a large number of active lichenologists relative to the number of species present in the biota and total land area. Hawksworth (2003) reported 403 species from Great Britain and Ireland, which is comparable to the number known from Spain. Thus we assert that the lichenicolous fungi of Spain can be considered relatively "well known." Other European countries or regions with active mycologists working on lichenicolous fungi also have

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comparable levels of reported diversity. For instance 430 lichenicolous fungi and 27 saprophytes have been reported from Fennoscandia (Santesson et al. 2004). Similarly 461 lichenicolous fungi have been reported from France (Roux 2012), 249 from Poland (Czyżewska & Kuwka 2009), 226 from the Czech Republic (Kocourková 2009b) and 201 from Belgium and Luxembourg combined (Diederich & Sérusiaux 2000). Although 491 lichenicolous fungi and 71 saprophytes have been reported from North America (Esslinger 2012), excluding Mexico, the number is not comparable to those above because of the significant incongruence in size, number of investigators, and collection intensity between regions. The same is likely applicable to Russia which has 276 reported lichenicolous fungi (Zhurbenko 2007).

We believe that the richness of lichenicolous fungi found on the Iberian Peninsula is due to the diversity of intact and conserved natural habitats. The northern and western coastal area has an oceanic climate and the eastern and south is Mediterranean. Although much of the coastal areas have been significantly degraded there are still some extensive and well preserved forests with a rich lichen flora, like Caaveiro in La Coruña (López de Silanes 1988), Muniellos in Asturias (Barreno & Pérez-Ortega 2003) and Bértiz in Navarra (Etayo 2002). Spain is also a very mountainous country with peaks in the central Pyrenees and Betic belt reaching approximately 3000 meters in elevation. Several doctoral theses and papers have been dedicated to these mountainous areas (Barreno & Pérez-Ortega 2003, Calatayud 1998, Etayo 2010, Rico 1989, Sancho 1986, Terrón 1991) and many more contributions were referenced in Llimona and Hladun (2001). There are also many areas of Mediterranean forest not studied yet. Of particular interest could be the “dehesa”, a kind of human-managed forest from western and mountain Mediterranean areas. Geologically speaking, exposed rocks on the Iberian Peninsula are acidic in the west half and basic in the east half. This variety of rocky types, together with the extensive outcrops at diverse elevations and in subdesert habitats supports a high diversity of saxicolous and terricolous lichens (Etayo 2010, Llimona 1973).

When one considers the inconspicuous nature of lichenicolous fungi it is not surprising that the most studied regions of the Iberian Peninsula tend to correspond to the areas nearby where active researchers are located. As such, the northeastern part of the Peninsula (Cataluña) has been sampled and studied intensively by Navarro-Rosinés and colleagues (e.g., Navarro-Rosinés & Hafellner 1996; Navarro-Rosinés et al. 2001, 2010; Navarro-Rosinés & Roux 1995, 1996). Calatayud and Atienza have published many papers focusing on the southern and eastern coastal areas of the Peninsula (Región Valenciana) (Atienza et al. 2003; Calatayud & Barreno 1994; Calatayud & Navarro-Rosinés 1998; Calatayud & Rico 1995; Calatayud & Triebel 2003; Calatayud et al. 1995, 2002, 2004, 2007). The lichenicolous fungi occurring on members of the Peltigerales have also been well studied, especially in the central portion of the peninsula near Madrid by Martínez (Martínez & Hafellner 1998). The first author has made several trips throughout Portugal, resulting in additional publications (van den Boom 2003, 2006; van den Boom & Etayo 2000; Diederich et al. 2012). The second author has collected and published extensively on the lichens of northern Spain, particularly Navarra and Aragón (Brackel et al. 2012; Diederich & Etayo 2000; Diederich et al. 2007; Etayo 1996, 1998, 2002, 2004, 2008, 2010; Etayo & Breuss 1996; Etayo & Diederich 1996; Etayo & Calatayud 1998; López de Silanes et al. 2009; Vondrak & Etayo 2007). Finally, Pérez-Ortega has collected throughout Spain and published a number of contributions on lichenicolous fungi (Barreno & Pérez-Ortega 2003; Pérez-Ortega & Etayo 2010; Pérez-Ortega & Álvarez-Lafuente 2006a, 2006b).

During the past twenty years both authors of the present contribution have studied lichens and lichenicolous fungi of Spain and Portugal, including the Canary Islands (Etayo & van den Boom 1995; van den Boom & Etayo 2000, 2001, 2006; van den Boom et al. 2009). As a result of numerous field trips we have collected many taxa that were not previously reported from the Iberian Peninsula or represent species apparently new to science. Here we publish a compilation of the most recent discoveries, including taxonomic novelties, range extensions, and new localities of taxa other already previously recorded. The goal of this contribution is to aggregate these discoveries into a single reference to aid in future attempts at documenting and understanding the distributions of species in the region.

## MATERIALS AND METHODS

This study is based on specimens collected by the authors during fieldtrips throughout the Iberian Peninsula from 1985 until 2012. These specimens have largely been deposited in the personal herbaria of the authors which are abbreviated “hb. van den Boom” and “hb. Etayo” throughout the text. In the cases of newly described taxa the holotypes have been deposited in BCN and isotypes in the herbaria of the authors.

All specimens were studied by conventional macro- and microscopical techniques with hand-cut sections of the material mounted in water, 10% KOH (K), Lugol's iodine, directly (I) or after a K pre-treatment (K/I) or HNO<sub>3</sub>. Ascomatal sizes were measured dry and ascospore sizes and other structures were measured in water.

## NEW REPORTS AND NEW SPECIES

The new reports and descriptions of new species are arranged alphabetically below. Throughout the text, the authorities are only given for species of lichenicolous fungi whereas those for the numerous host taxa mentioned are excluded.

### *Abrothallus parmeliarum* (Sommerf.) Arnold

NOTES. – Extensive references to reports of this species from the Iberian Peninsula are given by Llimona and Hladun (2001). We add here some new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 2 km E Lago del Valle, *Fagus* coppices along path to Lago del Valle, on *Parmelia sulcata*, 43°2.7'N, 6°8.6'W, 1400 m, 8.vii.2001, *P. & B. v.d. Boom* 27085 (hb. van den Boom). **LLEIDA:** WNW of Bellver de Cerdanya, NNW of Martinet, Ref. Cap de Pla del Rec, on *Parmelia saxatilis* on granite, 42°25.9'N, 1°40.0'E, 1940 m, 12.viii.1998, *P. v.d. Boom* 21505 (hb. van den Boom).

### *Arthonia apotheciorum* (A. Massal.) Almq.

NOTES. – This species was recently reported from one locality in Aragón (Etayo 2010). We add here a new locality.

*Specimen examined.* – **SPAIN. MALLORCA:** ENE of Soller, Sierra Torrellas, 0.8 km E of Son torrella, low calcareous outcrops in meadow, on *Lecanora albescens*, 975 m, 5.iv.1997, *P. v.d. Boom* 18579 (hb. van den Boom).

### *Arthonia clemens* (Tul.) Th. Fr.

NOTES. – This taxon has previously been reported from the Iberian Peninsula growing on several hosts. However it is likely that only the populations growing on *Rhizoplaca* belong to the species in a strict sense and according to Diederich (2003) the populations on *Lecanora* belong to several distinct species.

*Specimens examined.* – **SPAIN. GIRONA:** enclave Llivia, NE of Puigcerda, N of Cereja, Els Serrats, SW exposed slope, on *Rhizoplaca chrysoleuca* on granite boulder, 42°28.8'N, 1°58.2'W, 1350 m, 13.viii.1998, *P. v.d. Boom* 21545 (hb. van den Boom). **LLEIDA:** P.N. Aigües Tortes, on *R. chrysoleuca* in siliceous rock, *J. Etayo* 619 (hb. Etayo).

### *Arthonia fuscopurpurea* (Tul.) R. Sant.

NOTES. – This species was previously reported from the Iberian Peninsula from Cantabria (Martínez & Hafellner 1998, Pérez-Ortega & Álvarez-Lafuente 2006a) and Navarra (Etayo 2002). We add two more localities close to these.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 5.5 km ESE Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on *Peltigera rufescens*, 43°2.7'N, 6°8.6'W, 1570 m, 8.vii.2001, *P. & B. v.d. Boom* 27077 (hb. van den Boom). **NAVARRA:** Oronoz-Mugaie, Señorío de Bértiz, along the road to Aizcolegi, on *Peltigera* on slope, ca. 250 m, 15.xii.2001, *J. Etayo* 18668 (hb. Etayo).

### *Arthonia molendoi* (Heufl. ex Frauenf.) R. Sant.

NOTES. – This species was reported previously from the Iberian Peninsula by Calatayud et al. (1995) and Etayo (2010). We here add several new localities.

*Specimens examined.* – **SPAIN. LA RIOJA:** Tierra de Cameros, Gallinero de Cameros, forest in stream, 1000 m, 11.iv.1996, on *Xanthoria parietina* on undetermined trunk, *J. Etayo* 14287 (hb. Etayo); Sierra Cebollera, puerto de Piqueras, hostel near the stream, on *Caloplaca granulosa* on rock, 1400 m, 11.iv.1996, *J. Etayo* 14301 (hb. Etayo); Clavijo village, rockface below the hermitage, on *Caloplaca saxicola* gr., 870 m, 9.iii.2001, *J. Etayo* 18157 (hb. Etayo). **MURCIA:** WSW of Cartagena, N of Águilas, Cabo Cope, on *Caloplaca aurantia* on top of calcareous outcrop, 37°26.0'N, 1°29.1'W, 65 m, 14.vii.2005, *P. & B. v.d. Boom* 34888 (hb. van den Boom). **NAVARRA:** Fustiñana, Reserva Natural Caídas de la Negra

y Juego de Pelota, on *X. parietina* on a shrub, ca. 600 m, 26.ii.1995, *J. Etayo 15127* (hb. Etayo); Iragui, quejigal on slope, with a well-developed Xanthorion, on *X. parietina* on *Quercus faginea*, 700 m, 10.iii.1996, *J. Etayo 13809* (hb. Etayo). **SORIA:** Yanguas, on rockface near the church in the village, on *Caloplaca lobulata* on *Quercus ilex*, 1000 m, 16.v.1999, *J. Etayo 16990* (hb. Etayo).

#### ***Arthonia phaeophysciae* Grube & Matzer**

NOTES. – *Arthonia epiphyscia* Nyl. was mentioned many times by Llimona and Hladun (2001), however some of the reports of those authors are from the host genus *Phaeophyscia* rather than *Physcia*. The reports from *Phaeophyscia* may actually belong to *A. phaeophysciae* instead and should be re-examined. We add here several new localities for *A. phaeophysciae*.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, S of Grado, S of Proaza, W of Teverga, along road to Villanueva, near La Plaza, on *Phaeophyscia* on *Juglans*, 43°9.5'N, 6°7.1'W, 800 m, 8.vii.2001, *P. & B. v.d. Boom 26833* (hb. van den Boom). **NAVARRA:** Urdax, nearby the cave, on *Physciella* aff. *cloantha* on *Salix*, 50 m, 29.i.2002, *J. & A. Etayo 18287* (hb. Etayo), *J. & A. Etayo 18953* (hb. Etayo). **MURCIA:** WSW of Murcia, Parc Natural 'Sierra de Espuña', W of Alhama de Murcia, near crossing with road to El Berro, edge of *Pinus* forest and some *Quercus coccifera* trees at open place, on *P. orbicularis* on *Q. coccifera*, 37°51.15'N, 1°33.7'W, 1130 m, 2011, *P. & B. v.d. Boom 45873* (hb. van den Boom).

#### ***Arthonia urceolata* (Elenkin) Calat., Barreno & V.J. Rico**

NOTES. – This species has been recently reported from Huesca and Teruel (Calatayud et al. 2004, Etayo 2010). We add here a new locality of this species which appears to be rarely collected.

*Specimen examined.* – **SPAIN. SORIA:** Yanguas, on rockface near the church in the village, on *Aspicilia calcarea*, 1000 m, 16.v.1999, *J. Etayo 17005* (hb. Etayo), *J. Etayo 17012* (hb. Etayo).

#### ***Arthonia varians* (Davies) Nyl.**

NOTES. – *Arthonia varians* is a very common lichenicolous *Arthonia* species confined to *Lecanora rupicola*. We add here some new records of this species.

*Specimens examined.* – **SPAIN. GRANADA:** S<sup>a</sup> Nevada, Peñones de S. Francisco, on *Lecanora rupicola*, viii.1995, *J. Etayo & E. Ros 10737* (hb. Etayo). **LEÓN:** S of Ponferrada, Lago de Sanabria (W side), path from Ribadelago Viejo to San Martin, path along Río Tera, on *L. rupicola* on shaded vertical acid outcrops, 42°8.5'N, 6°45.2'W, 1100 m, 10.vii.2001, *P. & B. v.d. Boom 27175* (hb. van den Boom). **LLEIDA:** SSE of Bellver de Cerdanya, between Flans de Bor and Ref. dels Cortals de L'ingla, on *L. rupicola* on vertical sunny rock, 42°18.8'N, 1°48.6'E, 1700 m, 10.viii.1998, *P. v.d. Boom 21348* (hb. van den Boom). **SORIA:** road Duruelo de la Sierra, paraje de Castroviejo, on *Lecanora swartzii* on overhanging rock, 1600 m, 20.x.2001, *J. Etayo s.n.* (MA-Lich).

#### ***Arthonia* cf. *xanthoparmeliarum* Etayo**

NOTES. – The specimen cited below was found on *Xanthoparmelia pulla*, a brown species of *Xanthoparmelia* that would previously have been placed in the genus *Neofuscelia* (Blanco et al. 2004). The material is similar to *A. xanthoparmeliarum*, a taxon described from usnic acid producing *Xanthoparmelia* from southern Chile (Etayo & Sancho 2008). Although we have found slightly smaller ascospores (9–12 × 3.5–4.5 µm vs. 11–14.5 × 4–5 µm) and asci (24–30 × 12–17 µm vs. 32–37 × 14–17 µm), and more elongate paraphysal tips, it fits rather well the features of this species, found also in California, U.S.A. (Kocourková 2009) and Luxembourg (Eichler et al. 2010). As the sample is scanty we hesitantly assign it to *A. xanthoparmeliarum*. If the identification is confirmed would be the first record of the species from Spain.

*Specimen examined.* – **SPAIN. ALMERÍA:** S<sup>a</sup> de los Filabres, 18 km NWN of Sorbas, W of road Uleila del Campo to Albánchez, 1 km S of Pto. de la Virgen, on *Xanthoparmelia pulla* on shaded vertical acid rock, 1000 m, 14.vii.1989, *P. & B. v.d. Boom 8712* (hb. van den Boom).

#### ***Briancoppinsia cytospora* (Vouaux) Diederich, Ertz, Lawrey & van den Boom (= *Phoma cytospora* (Vouaux) D. Hawksw.)**

NOTES. – Diederich et al. (2012) reported this species from several parmelioid host species. The host genus *Hypogymnia* is, however, not mentioned in that paper and thus this appears to be a new host



genus for the taxon. In the collection from *Hypogymnia* cited below *Briancoppinsia cytospora* grows especially on the soralia of the host thallus.

*Specimens examined.* – **SPAIN. BURGOS:** Monterrubio de Demanda, km 28 near La Rioja province, oak forest of *Quercus pyrenaica*, on *Melanelixia subaurifera*, ca. 1100 m, 9.ii.1997, *J. Etayo* 14254 (hb. Etayo). **LA RIOJA:** Tierra de Cameros, road Villanueva de Cameros to ortigosa, in front of embalse González Lacasa, on *Melanelixia* on *Quercus* sp., 1010 m, 11.iv.1996, *J. Etayo* 14313 (hb. Etayo), on *Evernia prunastri* on *Quercus* sp. *J. Etayo* 14316 (hb. Etayo), on *Parmelia sulcata* on *Quercus* sp., *J. Etayo* 14317 (hb. Etayo). **LLEIDA:** SE of Bellver de Cerdanya, road from Riu to Coll del Pendis, Ref. Serrat de les Esposes, 42°19.8'N, 1°49.7'E, on *Hypogymnia* on *Pinus*, 1600 m, 10.viii.1998, *P. v.d. Boom* 21370 (hb. van den Boom).

### ***Caloplaca grimmiae* (Nyl.) H. Olivier**

NOTES. – This species has been reported several times from Spain, always growing on *Candelariella vitellina* (Hladun & Llimona 2002-2007). We provide two additional reports here.

*Specimens examined.* – **SPAIN. LLEIDA:** SSE of Bellver de Cerdanya, between Flans de Bor and Ref. dels Cortals de L'ingla, on *Candelariella vitellina* on vertical sunny rock, 42°18.8'N, 1°48.6'E, 1700 m, 10.viii.1998, *P. v.d. Boom* 21348 (hb. van den Boom). **SORIA:** Gallinero, Sierra de Montes Claros, in *Quercus pyrenaica* forest with *Fagus* and *Ilex*, on *C. vitellina* on sandstones, 41°9'N, 2°2'W, 1400 m, 22.xii.1998, *J. Etayo* 17136 (hb. Etayo), *J. Etayo* 17163 (hb. Etayo).

### ***Carbonea aggregantula* (Müll. Arg.) Diederich & Triebel**

NOTES. – Several recent records of this species from Huesca were published by Etayo (2010). We add here as provisional a new locality for Andorra on an unusual host of the genus *Rhizocarpon*.

*Specimens examined.* – **ANDORRA.** ENE of Andorra la Vella, Port d'Envalira, S slope with acid outcrops in meadow, on *Rhizocarpon*, 2400 m, 8.viii.1992, *P. v.d. Boom* 13617 (hb. van den Boom); on sterile crust of cf. *Lecidea* or *Lecanora*, *P. v.d. Boom* 13622 (hb. van den Boom).

### ***Carbonea vitellinaria* (Nyl.) Hertel**

NOTES. – This is a common lichenicolous fungus that occurs on *Candelariella vitellina*. Many references to it were included in Hladun and Llimona (2002-2007). We add here a number of new localities.

*Specimens examined.* – **ANDORRA.** ENE of Andorra la Vella, Port d'Envalira, S slope with acid outcrops in meadow, on *Candelariella vitellina*, 2400 m, 8.viii.1992, *P. v.d. Boom* 13622 (hb. van den Boom). **SPAIN. HUESCA:** Panticosa, on *C. vitellina* on quartz, 1991, *J. Etayo* 11056 (hb. Etayo); Valle de Tena, Biescas, N of de Peña Telera, Ibón de Piedrafita, on *C. vitellina*, 1600-1700 m, 1.x.1994, *J. Etayo* 12801 (hb. Etayo), *J. Etayo* 12806 (hb. Etayo). **NAVARRA:** Larra, Eskilzarra, near the mountain retreat, on *C. vitellina* on decalcified rocks, 1400 m, 29.viii.1995, *J. A. Azpilicueta & J. Etayo* 12862, *W. Müller & C. Serra s.n.* (hb. Etayo). **SORIA:** Gallinero, Sierra de Montes Claros, *Quercus pyrenaica* forest with *Fagus* and *Ilex*, 41°90'N, 2°20'W, 1400 m, 22.xi.1998, on *C. vitellina* on sandstones *J. Etayo* 17136 (hb. Etayo); road Duruelo de la Sierra, to paraje de Castroviejo, on *C. vitellina* on shaded rock, 1600 m, 2001, *J. Etayo* 18351 (hb. Etayo).

### ***Catillaria mediterranea* Hafellner**

NOTES. – *Catillaria mediterranea* was reported from Spain by Tretiach and Hafellner (1998), where it always occurs on *Anaptychia*. This is the first record of an occurrence of the taxon on *Squamarina*. *Catillaria mediterranea* could be confused with *C. nigroclavata*, a lichen that has also been collected on parmelioid hosts (Etayo 2010). However *C. mediterranea* can readily be distinguished from *C. nigroclavata* by its polysporous asci (vs. eight spored in *C. nigroclavata*). We add here several new localities.

*Specimens examined.* – **SPAIN. BURGOS:** Santo Domingo de Silos, Peñas de Cervera, sabinar nearby river Mataviejas, on *Anaptychia ciliaris* on *Juniperus thurifera*, ca. 900 m, 1997, *J. Etayo* 14250 (hb. Etayo). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, on *Squamarina*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, *P. v.d. Boom* 45915 (hb. van den Boom). **SORIA:** Sabinar de la Cueva del Agua, Villaciervos, on *A. ciliaris* on *J. thurifera*, ca. 1000 m, 1997, *J. Etayo* 14969 (hb. Etayo), *J. Etayo* 15510 (hb. Etayo).

***Cercidospora crozalsiana* (H. Olivier) Nav.-Ros, Cl. Roux & Casares**

NOTES. – Grube and Hafellner (1990) reported this species for the first time for the Iberian Peninsula. The distribution in Spain was given by Etayo (2010). We add here two new localities.

*Specimens examined.* – **SPAIN. ALMERÍA:** N rim of Sierra Cabrera, W of Mojácar, W of Turre, near bridge over Río de Aguas, on *Squamarina lentigera* on horizontal soil with shrubs and *Chamaerops humilis*, 37°8.48'N, 1°55.97'W, 90 m, 5.ix.2007, P. & B. v.d. Boom 38364 (hb. van den Boom). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, on *Squamarina cartilaginea*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, P. & B. v.d. Boom 45924 (hb. van den Boom).

***Cercidospora epicarphinea* (Nyl.) Grube & Hafellner**

NOTES. – This species differs from other members of the *Cercidospora caudata* group by its distinctly heteropolar spores and 8-spored asci (Navarro-Rosinés 2004). It lives on the thallus of several *Caloplaca* species. We add here several new localities to those known from the Iberian Peninsula.

*Specimens examined.* – **SPAIN. ALMERÍA:** Sierra del Cabo de Gata, SW of San José, path between Casa Mónsul to Torre de Vela Blanca, on *Caloplaca carphinea* on N exposed vertical rock, 36°43.85'N, 2°10.14'W, 75 m, 6.ix.2007, P. & B. v.d. Boom 38413 (hb. van den Boom). **CÁCERES:** NW of Guadalupe, Sierra de las Villuercas, Cabañas del Castillo, E slope with acid rocks under ruins, on *C. demissa*, on steep W exposed rock, 39°32.5'N, 5°30.5'W, 750 m, 21.vii.2001, P. & B. v.d. Boom 27276 (hb. van den Boom), on *C. carphinea*, P. & B. v.d. Boom 27269 (hb. van den Boom); 44 km NNW of Trujillo, P.N. de Monfragüe, SW of Villarreal de San Carlos, in front of Salto del Gitano, W exposed slope, on *C. carphinea* on acidic rock, 30°49.8'N, 6°3.8'W, 500 m, 19.vii.2001, P. & B. v.d. Boom 27221 (hb. van den Boom).

***Cercidospora macrospora* (Uloth) Hafellner & Nav.-Ros.**

NOTES. – *Cercidospora macrospora* was previously reported from the Iberian Peninsula by Calatayud and Barreno (1994) and Etayo (2010). We add here a new locality.

*Specimen examined.* – **SPAIN. SORIA:** Yanguas, on rockface near the church in the village, on *Lecanora muralis*, 1000 m, 16.v.1999, J. Etayo 17003 (hb. Etayo).

***Clypeococcum psoromatis* (A. Massal.) Etayo**

NOTES. – This taxon is a common fungus on several *Squamarina* species (Etayo 2010). We add several new localities here.

*Specimens examined.* – **SPAIN. ALMERÍA:** N rim of Sierra Cabrera, W of Mojácar, W of Turre, near bridge over Río de Aguas, on *Squamarina lentigera* on horizontal soil with shrubs and *Chamaerops humilis*, 37°8.48'N, 1°55.97'W, 90 m, 5.ix.2007, P. & B. v.d. Boom 38367 (hb. van den Boom). **MURCIA:** WSW of Cartagena, Sierra de la Muela, N of Campillo de Adentro, E of road Cartagena to El Puerto, on *Squamarina* sp. on N slope, 37°35.8'N, 1°8.3'W, 385 m, 16.vii.2003, P. & B. v.d. Boom 30884 (hb. van den Boom); S of Cartagena, NE of El Puerto, La Azohia, near Torre Santa Elena, on *Squamarina cartilaginea* on N slope, 37°32.9'N, 1°10.3'W, 110 m, 17.vii.2003, P. v.d. Boom 30896 (hb. van den Boom). **NAVARRA:** Fustiñana, Reserva Natural Caídas de la Negra y Juego de Pelota, ca. 600 m, 26.ii.1995, on *Squamarina cartilaginea* on rock fissures, J. Etayo 15119 (hb. Etayo); Bardenas Reales, Laguna de Rada, 370 m, 14.iii.1988, on *S. lentigera* on gypsiferous soil below pine wood, J. Etayo 14966 (hb. Etayo).

***Cyphelium sessile* (Pers.) Trevis.**

NOTES. – This species was previously reported several times from the Iberian Peninsula (Hladun & Llimona 2002-2007). We add here several new localities.

*Specimens examined.* – **SPAIN. SALAMANCA:** SW of Salamanca, Parc Natural 'Sierra de la Peña de Francia', 1 km E of La Alberca, Castaño, open forest with mature *Quercus pyrenaica* trees, and one very big *Castanea sativa* tree, on *Pertusaria*, 40°29.41'N, 6°5.7'W, 1030 m, 2011, P. & B. v.d. Boom 46096 (hb. van den Boom). **SORIA:** Rioseco, sabinar de Rioseco, on *Pertusaria* on *Juniperus thurifera*, ca. 1000 m, 1998, J. Etayo 16061 (hb. Etayo).

***Diploschistes muscorum* (Scop.) R. Sant.**

NOTES. – We found this species growing over mosses and parasitically on the squamules of *Cladonia rangiformis*. Here we report three new localities for the species from the Iberian Peninsula.

*Specimens examined.* – **SPAIN. CÁCERES:** 44 km NNW of Trujillo, P.N. de Monfragüe, E of Villarreal de San Carlos, E of Portilla del Tietar, on *Cladonia rangiformis* on W exposed slope, 30°50.4'N, 5°57.0'W, 500 m, 19.vii.2001, *P. & B. v.d. Boom* 27211 (hb. van den Boom). **MÁLAGA:** Ronda, S<sup>a</sup> de las Nieves, 2 km to cortijo de los quejigales, on *Cladonia* sp., on soil, 16.iv.1994, *J. Etayo* 1048 (hb. Etayo). **PALENCIA:** Aguilar de Campoó, near the castle, on bryophytes, ca. 1000 m, 19.iv.2001, *J. Etayo & E. Ros* 18103 (hb. Etayo).

***Endococcus pseudocarpus* Nyl.**

(=*Didymosphaeria pseudocarpa* (Nyl.) Sacc. & D. Sacc.)

NOTES. – This species is a specialized lichenicolous fungus on cyanobacterial lichens. We found it on *Peltula obscurans* and several *Collema* species. It was reported from Spain from Asturias, Huesca, Navarra, Palencia, Soria and Zaragoza (Etayo 2004, 2010; López de Silanes et al. 2009). We add here several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** Picos de Europa, SE of Arenas de Cabrales, S of Sotres along path from Vegas del Toro to Reg. de Aliva, on *Collema multipartitum* on vertical limestone, 1500 m, 25.vii.1989, *P. v.d. Boom* 9063 (hb. van den Boom). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, on *Collema* on vertical crevices, 36° 57.5'N, 4°32.5'W, 1200 m, 2011, *P. & B. v.d. Boom* 45905 (hb. van den Boom). **MURCIA:** WSW of Murcia, Parc Natural S<sup>a</sup> de Espuña, ENE of Aledo, Monasterio La Santa, *Pinus* forest with calcareous outcrops, on *Peltula obscurans* on rock, 37°47.9'N, 1°33.48'W, 615 m, 2011, *P. & B. v.d. Boom* 45859 (hb. van den Boom). **PALENCIA:** Aguilar de Campoó, near the castle, on *Collema* sp. in limestone fissures, ca. 1000 m, 19.vi.1991, *J. Etayo* 17109 & *E. Ros* (hb. Etayo). **SORIA:** Berlanga de Duero, natural area nearby the river, on *Collema* on limestone wall, 25.ix.1999, *J. Etayo* 18104 & *E. Ros* (hb. Etayo).

***Endohyalina insularis* (Arnold) Giralt, van den Boom & Elix**

(= *Rinodina insularis* (Arnold) Hafellner)

NOTES. – This species, a lichenicolous lichen that grows on the thallus of *Lecanora rupicola*, has been reported several times from the Iberian Peninsula (Hladun & Llimona 2002-2007). We add here several new localities.

*Specimens examined.* – **SPAIN. GIRONA:** 1.3 km NE of Meranges, 0.5 km further from crossing to Malniu/Feixa, on *Lecanora rupicola* on outcrop on vertical rock, 42°27.3'N, 1°48.0'E, 2000 m, 14.viii.1998, *P. v.d. Boom* 20602 (hb. van den Boom). **SORIA:** Gallinero, Sierra de Montes Claros, 41°90'N, 2°20'W, *Quercus pyrenaica* forest with *Fagus* and *Ilex*, on *L. rupicola* on sandstones, 1400 m, 22.ix.1998, *J. Etayo* 17164 (hb. Etayo), *J. Etayo* 17118 (hb. Etayo), *J. Etayo* 17119 (hb. Etayo), *J. Etayo* 17134 (hb. Etayo).

***Epiclادonia stenospora* (Harm.) D. Hawksw.**

NOTES. – Reports of this species from several localities in northwestern Spain were published by Hladun and Llimona (2002-2007). We here add two new localities.

*Specimens examined.* – **SPAIN. LEÓN:** SE of Ponferrada, along road La Bañeza to Puebla de Sanabria, 0.5 km E of Castrocontrigo, on terricolous *Cladonia* squamules, 42°11.2'N, 6°11.3'W, 900 m, 9.vii.2001, *P. & B. v.d. Boom* 27153 (hb. van den Boom). **NAVARRA:** Espinal, Arizarte, on *Cladonia* on stump, 30.v.1993, *J. Etayo* 3453 (hb. Etayo).

***Halecania giraltiae* van den Boom & Etayo**

NOTES. – Van den Boom and Etayo (2001) described this species from northern Portugal and central Spain. Here we add another locality for this rare species.

*Specimen examined.* – **SPAIN. SALAMANCA:** SW of Salamanca, Parc Natural 'Sierra de la Peña de Francia', on the top (Peña de Francia), acidic outcrops in open area, on *Aspicilia*, 40°30.8'N, 6°10.2'W, 1700 m, 2011, *P. & B. v.d. Boom* 46080 (hb. van den Boom).

***Illosporium carneum* Fr.**

NOTES. – Martínez and Hafellner (1998) gave an overview of the distribution of this taxon, known on the Iberian Peninsula from three provinces, including Asturias. Our specimen was found growing together with *Leptosphaerulina peltigerae* on the same host.

*Specimen examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 5.5 km ESE Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on *Peltigera rufescens*, 43°2.7'N, 6°8.6'W, 1570 m, 8.vii.2001, P. & B. v.d. Boom 27077b (hb. van den Boom).

***Intralichen lichenicola* (M.S. Christ. & D. Hawksw.) D. Hawksw. & M.S. Cole**

NOTES. – *Intralichen lichenicola* is a common species that has been rarely reported from the Iberian Peninsula (Etayo 2010). We suspect that the lack of previous reports may be due to its cryptic appearance. We add here two new localities.

*Specimens examined.* – **SPAIN. MURCIA:** WSW of Cartagena, N of Águilas, Cabo Cope, on *Caloplaca aurantia* on top of calcareous outcrop, 37°26.0'N, 1°29.1'W, 65 m, 14.vii.2005, P. & B. v.d. Boom 34888 (hb. van den Boom); SW of Cartagena, S<sup>a</sup> del Algarrobo, NW of Mazarrón, 2 km S of La Pinilla, on *Candelariella aurella* and *Caloplaca aurantia* on stones, 37°40.0'N, 1°17.0'W, 305 m, 16.vii.2005, P. & B. v.d. Boom 34886 (hb. van den Boom).

***Labrocarpon canariense* (D. Hawksw.) Etayo & Pérez-Ortega**

NOTES. – This species has frequently been reported from the Canary Islands (e.g., van den Boom & Etayo 2006), but it has only rarely been reported from the mainland Iberian Peninsula, where it was known only from Almería (Calatayud et al. 1995) and Portugal (Pérez-Ortega & Etayo 2010, van den Boom 2006). We add here one new locality.

*Specimen examined.* – **SPAIN. ALMERÍA:** road between Sopalmo and Carboneras, coastal mountains, on *Pertusaria* on shaded, N sloping outcrop, 37°2.75'N, 1°52.51'W, 165 m, 10.ix.2007, P. & B. v.d. Boom 38504 (hb. van den Boom).

***Leptosphaeria ramalinae* (Desm.) Sacc.**

NOTES. – To date, this species had been reported only from Mallorca and Castellón on the Iberian Peninsula (Etayo 1996, Santesson 2001). Here we report it as new to Cádiz, Huelva, Málaga, Salamanca and Navarra. From the latter province, Etayo (1996) previously reported it without locality.

*Specimens examined.* – **SPAIN. CÁDIZ:** Jerez de la Frontera, km 41 in the road C3331, *Quercus suber* wood, on *Ramalina calicaris* on rock, 36°35.2'N, 05°30.9'W, 17.iv.1994, J. Etayo et al. 12317 (hb. Etayo). **HUELVA:** W of Aracena, S<sup>a</sup> de la Virgen, road from Fuenteheridos to Alájar, trail “La Urralera”, on *Ramalina* sp. on *Pistacia*, 37°53.41'N, 6°39.88'W, 800 m, 13.ix.2007, P. & B. v.d. Boom 38630 (hb. van den Boom). **NAVARRA:** S<sup>a</sup> de Illón, monte Belbún, Navascués, 2 km from Castillonuevo, on *R. fastigiata* on undetermined tree, ca. 1250 m, 11.vi.1994, J. Etayo 12433 (hb. Etayo). **SALAMANCA:** Linares de Riofrío, on *Ramalina* on *Q. pyrenaica*, 26.ix.1991, J. Etayo 856 (hb. Etayo).

***Leptosphaerulina peltigerae* (Fuckel) Riedl**

NOTES. – In the specimen cited below we found this species growing together with *Illosporium carneum* on *Peltigera rufescens*. There are only a few Spanish records of this taxon, all from Navarra and Teruel (Martínez & Hafellner 1998).

*Specimen examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 5.5 km ESE Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on *Peltigera rufescens*, 43°2.7'N, 6°8.6'W, 1570 m, 8.vii.2001, P. & B. v.d. Boom 27077 (hb. van den Boom).

***Lichenochora obscuroides* (Linds.) Triebel & Rambold**

NOTES. – References to several records from Spain are cited in Hladun and Llimona (2002-2007). As it is not a frequently reported species we provide several new reports of it here.

*Specimens examined.* – **SPAIN. NAVARRA:** valle de la Ulzama, Lanz, XN1262, ca. 600 m, 1985, on *Phaeophyscia orbicularis* on *Fraxinus*, J. Etayo 5706 (hb. Etayo); Sierra de Urbasa, Cargadero, WN7245, 920 m, 1991, on *P. orbicularis* on branches of *Acer*, J. Etayo 5816 (hb. Etayo), on the same host on a mature *Fagus*, J. Etayo 5947 (hb. Etayo). **VALENCIA:** SW of Valencia, WNW of Moixent, NNW of Navalón de Arriba, NW of El Puntal, *Olea* trees and *Juglans* trees along field, small *Pinus* forest, with shaded outcrops along trail, on *P. orbicularis* on *Juglans*, 38°56.3'N, 0°54.0'W, 850 m, 11.vi.2009, P. & B.



v.d. Boom 43177 (hb. van den Boom), on *P. orbicularis* on *Quercus*, P. & B. v.d. Boom 43174 (hb. van den Boom).

***Lichenochora verrucicola* (Weddl.) Nik. Hoffm. & Hafellner**

NOTES. – In the study area this species has previously been reported only from Tarragona (Hoffmann & Hafellner 2000) and Navarra (Etayo 2008). We add here a new locality.

*Specimen examined.* – **SPAIN. SORIA:** Yanguas, on rockface near the church in the village, on *Aspicilia contorta*, 1000 m, 16.v.1999, J. Etayo 16994 (hb. Etayo).

***Lichenochora weilii* (Werner) Hafellner & R. Sant.**

NOTES. – This species was described by Werner (1937) from Spain and since then rarely recorded. We add here two new localities.

*Specimens examined.* – **SPAIN. BURGOS:** Santo Domingo de Silos, Peñas de Cervera, sabinar nearby the river Mataviejas, on *Physconia* on *Juniperus thurifera*, ca. 900 m, 1997, J. Etayo 14249 (hb. Etayo). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs (*Crataegus*) and small trees, 36°57.5'N, 4°32.5'W, 1200 m, 2011, on *Physconia* on small tree, P. & B. v.d. Boom 45932 (hb. van den Boom), P. & B. v.d. Boom 45952 (hb. van den Boom).

***Lichenocodium erodens* M.S. Christ. & D. Hawksw.**

NOTES. – *Lichenocodium erodens* is a common lichenicolous fungus known to occur on several unrelated genera of lichens (Hawksworth 1981, Kocourková 2000). Here we report it from several genera, *Brodoa*, *Lecanora*, *Ramalina* and *Rhizoplaca*, some of them previously unknown as hosts for the taxon.

*Specimens examined.* – **SPAIN. GIRONA:** 1 km NE of Meranges, 1 km before crossing to Malniu/Feixa, on *Rhizoplaca chrysouleuca* on sloping rock, 42°27.2'N, 1°47.8'E, 1950 m, 14.viii.1998, P. v.d. Boom 21607 (hb. van den Boom), *Brodoa*, P. v.d. Boom 21610 (hb. van den Boom). **HUELVA:** W of Aracena, S<sup>a</sup> de la Virgen, road from Fuenteheridos to Castaño del Robledo, 0.5 km E of Campsite, on *Ramalina farinacea* on *Castanea*, 37°54.2'N, 6°40.1'W, 640 m, 12.ix.2007, P. & B. v.d. Boom 38558 (hb. van den Boom). **LLEIDA:** 8 km SSE of Bellver de Cedanya, Coll del Pendis, on *Lecanora saligna* on decorticated *Pinus*, 1760 m, 42°18.0'N, 1°48.0'E, 10.viii.1998, P. v.d. Boom 21399 (hb. van den Boom).

***Lichenocodium xanthoriae* M.S. Christ.**

NOTES. – This species was previously known in the study area from Cataluña (Giralt 1996) and Navarra (Etayo 2008) in Spain and Serra da Estrela in Portugal (van den Boom & Etayo 2000). We here add two records that we found growing on two unusual hosts, *Parmelina quercina* and *Physcia leptalea*.

*Specimens examined.* – **SPAIN. HUELVA:** W of Aracena, S<sup>a</sup> de la Virgen, road from Fuenteheridos to Alájar, trail “La Urralera”, on *Physcia leptalea* on shrub, 37°53.41'N, 6°39.88'W, 800 m, 13.ix.2007, P. & B. v.d. Boom 38631 (hb. van den Boom). **SORIA:** Valonsadero, on *Parmelina quercina* on *Juniperus*, 10.vi.1995, J. Etayo 13110 & B. Izquierdo (hb. Etayo).

***Lichenodiplis lecanorae* (Vouaux) Dyko & D. Hawksw.**

NOTES. – This species occurs on a wide array of host genera. The specimens listed here were found growing on *Caloplaca*, *Lecanora* and *Pertusaria*. Despite the wide array of hosts, the specimens fit the description published by Diederich (2003).

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, ESE of Pola de Somiedo, S of Vallar de Vildas, Braña la Pornacal, on *Lecanora hagenii* on *Sambucus*, 43°4.3'N, 6°19.5'W, 1100 m, 7.vii.2001, P. & B. v.d. Boom 26955 (hb. van den Boom). **ALMERÍA:** WSW of Lorca, Sierra Estancias, Pto de Sta. María de Nieva, N side of the top, on N exposed slope, on *Caloplaca* on *Quercus coccifera*, 37°34.64'N, 2°1.72'W, 1005 m, 8.ix.2007, P. & B. v.d. Boom 38437 (hb. van den Boom). **MALLORCA:** E side of island, E of Felanitx, Santuario San Salvador, just below the top, S sloping wood, on *Pertusaria* on *Olea*, 250 m, 3.iv.1997, P. v.d. Boom 18524 (hb. van den Boom). **SORIA:** Yanguas, on rockface near the church in the village, on *Caloplaca lobulata* on branches of *Quercus ilex*, 1000 m, 16.v.1999, J. Etayo 16990 (hb. Etayo). **VALENCIA:** SSE of Valencia, SSE of Xàbia, Cap de la Nau, near lighthouse, some *Pinus* trees, mixed shrubs (*Juniperus*, *Olea*, *Pistacia*) and calcareous outcrops, on *Caloplaca* sp., on *Olea*, 38°44.0'N, 0°13.7'E, 35 m, 15.vi.2009, P. & B. v.d. Boom 43209 (hb. van den Boom).

***Lichenostigma canariense* Etayo & van den Boom**

NOTES. – This seems to be the first record of this very small species from continental Europe. It was originally described from the Canary Islands by van den Boom and Etayo (2006).

*Specimens examined.* – **SPAIN. MURCIA:** SW of Cartagena, S<sup>a</sup> del Algarrobo, NW of Mazarrón, 2 km S of La Pinilla, on *Aspicilia calcarea* on stones, 37°40.0'N, 1°17.0'W, 305 m, 16.vii.2005, *P. & B. v.d. Boom* 34867 (hb. van den Boom), *P. & B. v.d. Boom* 34889 (hb. van den Boom).

***Lichenostigma diploiciae* Calat., Nav.-Ros. & Hafellner**

NOTES. – We here report a second locality of this species from Almería.

*Specimen examined.* – **SPAIN. ALMERÍA:** N rim of Sierra Cabrera, W of Mojácar, W of Turre, near bridge over Río de Aguas, on *Diploicia subcanescens* on vertical rock, on grassy slope with shrubs and *Chamaerops humilis*, 37°8.48'N, 1°55.97'W, 90 m, 5.ix.2007, *P. & B. v.d. Boom* 38382 (hb. van den Boom).

***Lichenostigma elongatum* Nav.-Ros. & Hafellner**

NOTES. – In Spain this species has been reported from Almería, Murcia, Zaragoza, Cataluña (Navarro-Rosinés & Hafellner 1996), La Rioja, Navarra (Etayo & Breuss 1996), Aragón (Etayo 2010) and Toledo (van den Boom & Etayo 2000). We here add several new localities.

*Specimens examined.* – **SPAIN. HUESCA:** Valle de Tena, Biescas, northern slope of Peña Telera, Ibón de Piedrafita, on *Lobothallia radiosa*, 42°42'N, 0°21.7'W, 1600-1700 m, 10.ix.1994, *J. Etayo* 12807 (hb. Etayo); Javierrelatre, valle de Serrablo, on *L. radiosa* on sandy limestone, 700 m, 6.xii.1993, *J. Etayo* 13876 & *E. Ros* (hb. Etayo). **MURCIA:** S of Cartagena, Cabo Tiñoso, near transmitter mast, on *Aspicilia calcarea* on N sloping rock, 37°33.1'N, 1°9.2'W, 370 m, 19.vii.2003, *P. & B. v.d. Boom* 30941 (hb. van den Boom); S of Cartagena, NE of El Puerto, La Azohia, near Torre Santa Elena, on *A. calcarea* on N slope, 37°32.9'N, 1°10.3'W, 110 m, 17.vii.2003, *P. v.d. Boom* 30894 (hb. van den Boom); SW of Cartagena, S<sup>a</sup> del Algarrobo, NW of Mazarrón, 2 km S of La Pinilla, on *A. calcarea* on stones, 37°40.0'N, 1°17.0'W, 305 m, 16.vii.2005, *P. & B. v.d. Boom* 34889 (hb. van den Boom). **NAVARRA:** Larra, on S exposed rockface, on *A. calcarea* on limestones, 1600 m, 22.x.1995, *J. Etayo* 13056 (hb. Etayo). **SORIA:** Yanguas, on rockface near the church in the village, on *A. calcarea*, 1000 m, 16.v.1999, *J. Etayo* 17012 (hb. Etayo).

***Lichenostigma epipolinum* Nav.-Ros., Calat. & Hafellner**

NOTES. – This is a common species already reported from the Iberian Peninsula by Calatayud et al. (2002) and Etayo (2008, 2010). We here add an additional locality.

*Specimen examined.* – **SPAIN. MURCIA:** WSW of Murcia, Parc Natural ‘Sierra de Espuña’, W of Alhama de Murcia, between crossing of La Perdiz and road to Gebas, *Pinus* forest with open places and some calcareous outcrops, on *Diploctoma*, 37°52.53'N, 1°29.76'W, 775 m, 2011, *P. & B. v.d. Boom* 45895 (hb. van den Boom).

***Lichenothelia rugosum* (G.Thor) Ertz & Diederich**

NOTES. – Many occurrences of this species from the Iberian Peninsula were published by Hladun and Llimona (2002-2007). Here we provide two new records of this common species that grows on *Diploschistes*.

*Specimens examined.* – **SPAIN. HUESCA:** Campo de Troyas, track Corral de las Mulas, on *Diploschistes scruposus*, 2150 m, 4.viii.1993, *J. Etayo* 11918 (hb. Etayo). **NAVARRA:** Gallipienzo nuevo, ca. 1 km from the village crossing the bridge over conglomerates, on *D. actinostomus*, 20.vii.1993, *J. Etayo* 14359 (hb. Etayo).

***Marchandiobasidium aurantiacum* Diederich & Schultheis**

NOTES. – In Etayo and Diederich (1996) this species was reported from Málaga and Navarra in Spain. Here we add records from La Rioja, Lleida and Valencia. In the specimens cited below we found only the anamorph, which is much more common than the teleomorph based on our study.

*Specimens examined.* – **SPAIN. LA RIOJA:** Tierra de Cameros, Gallinero de Cameros, grove near stream, on *Physcia adscendens* on *Quercus*, 1000 m, 11.iv.1996, *J. Etayo* 14278 (hb. Etayo); Soto de Cameros, cross with Trevijano, 770 m, oak forest of *Q. faginea*, on *Physcia semipinnata*, 9.iii.2001, *J. Etayo* 18183 (hb. Etayo); Fuentefría, recreational area between El Rasillo and Nieva de Cameros, on *P. adscendens* on *Fagus*, 930 m, 14.iv.2001, *J. Etayo* 18198 (hb. Etayo). **LLEIDA:** W of Bellver de

Cerdanya, NNW of Martinet, 0.5 km N of Travesseres, on *P. semipinnata* and *Xanthoria parietina* on *Q. pyrenaica*, 42°23.0'N, 1°41.3'E, 1275 m, 12.viii.1998, *P. & B. v.d. Boom* 21514 (hb. van den Boom). **VALENCIA:** SW of Valencia, WNW of Moixent, E of Navalón de Arriba, Serra de Enguera, open *Pinus / Quercus coccifera* forest with mixed shrubs and calcareous outcrops, on *P. semipinnata*, 38°55.5'N, 0°50.2'W, 700 m, 9.vi.2009, *P. & B. v.d. Boom* 43144 (hb. van den Boom).

***Marchandiomyces corallinus* (Roberge) Diederich & D. Hawksw.**

NOTES. – *Marchandiomyces corallinus* was reported by Etayo and Diederich (1996) from Girona and Navarra. It was also reported by Calatayud et al. (1995) and Etayo (2010) from Aragón. Here we expand its known distribution in the region to include Cáceres and Soria.

*Specimens examined.* – **SPAIN. CÁCERES:** NW of Guadalupe, Sierra de las Villuercas, Cabañas del Castillo, on *Xanthoria parietina* on *Quercus ilex*, 39°32.5'N, 5°30.5'W, 750 m, 21.vii.2001, *P. & B. v.d. Boom* 27248 (hb. van den Boom). **SORIA:** Yanguas, on rockface near the church in the village, on *Physcia caesia*, 1000 m, 16.v.1999, *J. Etayo* 16988 (hb. Etayo).

***Milospium graphideorum* (Nyl.) D. Hawksw.**

NOTES. – This species is common on lichens with a *Trentepohlia* photobiont growing in shaded localities. We here add several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** between Sueve and the coast, road between Bajada de Fito and Coceña, on steril lichen, on *Castanea* trunk, 9.v.1992, *J. Etayo* (MA-233); Sierra del Sueve abajo, La Corteguera stream, on steril on *Castanea*, 9.v.1992, *J. Etayo* (MA-239); Columbres, Archivo de Indianos garden, *Tilia* and *Magnolia*, on *Arthonia impolita* on *Tilia*, 110 m, 20.vii.1996, *J. Etayo* 14490 (hb. Etayo), on *Opegrapha varia* on wood, *J. Etayo* 14491 (hb. Etayo). **MALLORCA:** E side of island, Porto Pero, small *Pinus halepensis* wood, on sterile *Arthonia*[?] on *Pinus*, 50 m, 3.iv.1997, *P. & B. v.d. Boom* 18452 (hb. van den Boom).

***Muellerella erratica* (A. Massal.) Hafellner & V. John**

(= *Muellerella pygmaea* var. *athallina* (Müll.Arg.) Triebel)

NOTES. – This taxon was reported from the Iberian Peninsula by Triebel (1989) and subsequent authors (Etayo 2010, van den Boom & Etayo 2000, Vondrák & Etayo 2007). We here add two new localities.

*Specimens examined.* – **SPAIN. ALMERÍA:** W of Lorca, Sierra de María, W of María, on *Caloplaca variabilis* on N sloping outcrop, 37°41.68'N, 2°11.54'W, 1335 m, 8.ix.2007, *P. & B. v.d. Boom* 38459 (hb. van den Boom). **SORIA:** Yanguas, on rockface near the church in the village, on *Aspicilia calcarea*, 1000 m, 16.v.1999, *J. Etayo* 17001 (hb. Etayo), on *Caloplaca dalmatica*, *J. Etayo* 17002 (hb. Etayo).

***Muellerella hospitans* Stizenb.**

NOTES. – References to Iberian records of this species were published in Hladun and Llimona (2002-2007). We here add a new locality.

*Specimen examined.* – **SPAIN. MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, 36°57.5'N, 4°32.5'W, 1200 m, 2011, on *Bacidia* on tree, *P. & B. v.d. Boom* 45961 (hb. van den Boom).

***Muellerella lichenicola* (Sommerf.) D. Hawksw.**

NOTES. – This species has frequently been reported from the Iberian Peninsula (Llimona & Hladun 2001). We add here two new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, S of Grado, Tameza, centre of village, on *Caloplaca flavovirescens* on shaded wall of old church, 43°14.7'N, 6°6.8'W, 800 m, 3.vii.2001, *P. & B. v.d. Boom* 26775 (hb. van den Boom); SW of Oviedo, S of Grado, S of Proaza, along río Teverga, 1 km N of Teverga, on *Aspicilia calcarea* on limestone outcrops, 43°10.9'N, 6°5.3'W, 800 m, 4.vii.2001, *P. & B. v.d. Boom* 26817 (hb. van den Boom).

***Muellerella pygmaea* (Körb.) D. Hawksw. sens. str.**

NOTES. – This is a common species on the Iberian Peninsula (Llimona & Hladun 2001). We report several additional new localities here.

*Specimens examined.* – **SPAIN. ASTURIAS:** Picos de Europa, 7.5-10 km SE of Covadonga, path from Lago de la Ercina to Llaguuello, on *Lecanora* cf. *semipallida* on limestone on slope with scattered *Fagus*, 1250 m, 24.vii.1989, P. & B. v.d. Boom 9016 (hb. van den Boom). **CANTABRIA:** Picos de Europa, near Mirador El Cable NW of Espinama on *Caloplaca* sp. on calcareous rock, 1800 m, 30.vii.1987, P. & B. v.d. Boom 6240 (hb. van den Boom). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, 36°57.5'N, 4°32.5'W, 1200 m, 2011, on *Aspicilia calcarea*, P. & B. v.d. Boom 45922 (hb. van den Boom). **MURCIA:** SW of Cartagena, S<sup>a</sup> del Algarrobo, NW of Mazarrón, 2 km S of La Pinilla, on *Aspicilia calcarea* on stones, 37°40.0'N, 1°17.0'W, 305 m, 16.vii.2005, P. & B. v.d. Boom 34889 (hb. van den Boom).

***Muellerella ventosicola* (Mudd) D. Hawksw.**

NOTES. – This species was reported from the Iberian Peninsula by Triebel (1989) and has scarcely been recorded afterwards. We add a new locality here.

*Specimen examined.* – **SPAIN. ASTURIAS:** 35 km of Cangas de Onís, 10 km W of Panes, 0.7 km S of Trescares, on *Aspicilia melanaspis* on exposed well lit limestone, 250 m, 23.vii.1989, P. v.d. Boom 8965 (hb. van den Boom).

***Muellerella vesicularia* (Linds.) D. Hawksw.**

NOTES. – Here we report the second Iberian record of this species. The first record was published by Etayo (2010) who reported it was occurring on *Romjularia lurida*.

*Specimen examined.* – **SPAIN. CANTABRIA:** Picos de Europa, NW of Espinama, 200 m, NW of Horcadina de Cobarrobres, on *Toninia rosulata*, 1950 m, 30.vii.1987, P. v.d. Boom 6216 (hb. van den Boom).

***Nectriopsis hirta* Etayo**

NOTES. – *Nectriopsis hirta* was described as occurring on *Pertusaria* and an unidentifiable sterile lichen, both from northern Spain (Etayo 2010b). A similar species, *N. physciicola* D. Hawksw. & Earland-Benn. was described earlier from species of *Physcia* (Earland-Bennett et al. 2006). That species differs from *N. hirta* in having pinkish, less hairy perithecia, with a red colour in the apex (vs. brownish in color throughout and densely hairy), the absence of a pinkish hairy subiculum, thinner hairs (2-4 µm vs. 5-6 µm wide) and smaller spores that are not mucronate, ((14–)14.5–18(–22.5) × 5.5–8 µm vs. 16–29 × 7.5–10.5 µm).

Here we report *N. hirta* from an additional locality in Navarra as well as one in Málaga. At the latter locality we observed it growing not only on *Pertusaria*, but also on a small sample of *Physcia* to which it probably had spread from nearby *Pertusaria* thalli. Additional studies are required to ascertain the status of these two related *Nectriopsis*, but the morphological differences outlined above were evident in our material.

*Specimens examined.* – **SPAIN. MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, on *Physcia* on *Prunus spinosa*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, P. & B. v.d. Boom 45946 (hb. van den Boom), on *Pertusaria pertusa* on *Crataegus*, P. v.d. Boom 45929 (hb. van den Boom). **NAVARRA:** Unzué, Peña de Unzué, oak forest near the top, on *Pertusaria albescens* on *Quercus rotundifolia*, 42°39.23'N, 1°36.54'W, 900 m, 2012, J. Etayo 27833 (hb. Etayo).

***Nectriopsis lecanodes* (Ces.) Diederich & Schroers**

NOTES. – This species is very common on members of the Peltigerales and is known from a wide range of other hosts (Etayo & Diederich 1996). Hladun and Llimona (2002-2007) gave relatively few references for this species in Spain. We here add several new localities.

*Specimens examined.* – **SPAIN. LEÓN:** S of Ponferrada, S of Lago de Sanabria, S of Lubián, along road to Hermisende, *Quercus* forest, on *Lobaria scrobiculata* on *Quercus*, 42°01.9'N, 6°24.8'W, 1100 m, 11.vii.2001, P. & B. v.d. Boom 27196 (hb. van den Boom). **MÁLAGA:** Ronda, S<sup>a</sup> de las Nieves, 2 km before cortijo de los quejigales, 1050 m, 1994, on *Nephroma laevigatum* on *Q. rotundifolia*, J. Etayo 1042 (hb. Etayo), J. Etayo 14345 (hb. Etayo), J. Etayo 14346 (hb. Etayo), on *Dendriscocaulon* on *Q. rotundifolia*,



*J. Etayo 12081* (hb. Etayo). **PORTUGAL.** Tras-os-Montes, NW of Bragança, Mofreita, S of village, on *Lobaria pulmonaria* on *Castanea*, 900 m, 8.viii.1997, *P. v.d. Boom 19381* (hb. van den Boom).

***Neolamya peltigerae* (Mont.) Theiss. & H. Syd.**

NOTES. – Distribution of this rarely reported fungus from Europe and North America appears in Kocourková (2009). The specimen cited below seems to be the first record for the Iberian Peninsula.

*Specimen examined.* – **SPAIN. GIRONA:** 1 km NE of Meranges, 1 km before crossing to Malniu/Feixa, on a small *Peltigera* specimen, on sloping rock, 42°27.2'N, 1°47.8'E, 1950 m, 14.viii.1998, *P. v.d. Boom 21619* (hb. van den Boom).

***Niesslia cladoniicola* D. Hawksw. & W. Gams**

NOTES. – This species has rarely been reported from Europe. Although reported from the Canary Islands (Hafellner 1996) it has not previously been reported from mainland Spain.

*Specimen examined.* – **SPAIN. CÁCERES:** 44 km NNW of Trujillo, P.N. de Monfragüe, E of Villarreal de San Carlos, E of Portilla del Tietar, on *Cladonia rangiformis* on W exposed slope, 30°50.4'N, 5°57.0'W, 500 m, 19.vii.2001, *P. & B. v.d. Boom 27211* (hb. van den Boom).

***Obryzum corniculatum* Wallr.**

NOTES. – This appears to be the first record of *Obryzum corniculatum* from the Iberian Peninsula. Hoffmann and Hafellner (2000) reported it from Algeria, Austria, Greece, Great Britain, Italy, Portugal (Madeira) and Sweden.

*Specimen examined.* – **SPAIN. CÁDIZ:** NNW of Grazalema, Parc Natural Sierra de Grazalema, trail “Ruta del Pinsapar”, W of road CA-9104, to Benamahoma, N exposed slope with *Quercus coccifera*, *Abies pinsapo* and calcareous outcrops, 36°46.9'N, 5°24.2'W, 860 m, 2011, on *Leptogium lichenoides* on rock, *P. & B. v.d. Boom 46044* (hb. van den Boom).

***Opegrapha pulvinata* Rehm**

NOTES. – This species was recently reported from the Iberian Peninsula by Pérez-Ortega and Álvarez-La Fuente (2006b) and Etayo (2010). We add an additional locality here.

*Specimen examined.* – **SPAIN. MADRID:** about 52 km NW of the town, S<sup>a</sup> d Guadarrama, Río Lozoya, mountain slope with *Pinus sylvestris* with granite outcrops, on small *Dermatocarpon* on soil on an almost vertical granite rockwall, 12.v.2006, *S.N. Christensen 13529* (C).

***Paranectria oropensis* (Ces. ex Rabenh.) D. Hawksw. & Piroz.**

NOTES. – References to several Spanish reports of this species were given in Hladun and Llimona (2002-2007). We here add an additional locality.

*Specimen examined.* – **SPAIN. SALAMANCA:** SW of Salamanca, Parc Natural ‘Sierra de la Peña de Francia’, Miranda del Castañar, S of campsite, trail along forest with *Quercus pyrenaica*, fields and acidic stones on wall, 40°28.3'N, 6°0.0'W, 700 m, 2011, on *Physconia* on *Q. pyrenaica*, *P. & B. v.d. Boom 46054* (hb. van den Boom).

***Phacographa glaucomaria* (Nyl.) Hafellner**

(= *Opegrapha glaucomaria* (Nyl.) Källsten ex Hafellner)

NOTES. – This species was reported several times from the Iberian Peninsula by Llimona and Hladun (2001). We here add several additional localities.

*Specimens examined.* – **SPAIN. GIRONA:** 1.3 km NE of Meranges, 0.5 km further from crossing to Maljniu/Feixa, on *Lecanora rupicola* on sloping rock, 42°27.3'N, 1°48.0'E, 2000 m, 14.viii.1998, *P. v.d. Boom 21574* (hb. van den Boom). **NAVARRA:** Isaba, Refugio de Belagua, rockfaces 100 m W of the mountain retreat, on *L. rupicola*, 24.ix.1995, *J. Etayo 1766* (hb. Etayo). **SORIA:** Gallinero, Sierra de Montes Claros, *Quercus pyrenaica* forest with *Fagus* and *Ilex*, on *L. rupicola* on sandstone, 1400 m, 41°9'N, 2°2'W, 22.xi.1998, *J. Etayo 17160* (hb. Etayo).

***Phacographa zwackhii* (A. Massal. ex Zwackh) Hafellner**

NOTES. – Etayo (2010) summarized the few known records of this species from Spain. We here report a new locality.

*Specimen examined.* – **SPAIN. MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, 36°57.5'N, 4°32.5'W, 1200 m, 2011, on *Phlyctis argena*, P. & B. v.d. Boom 45944 (hb. van den Boom).

***Phacopsis fusca* (Triebel & Rambold) Diederich**

NOTES. – Van den Boom (2003) reported this taxon from Portugal under the name *Phacopsis oxyspora* var. *fusca* Triebel & Rambold. The specimens cited below represent the first records of the species from Spain.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, S of Pola de Somiedo, 4.5 km N of Puerto de Somiedo, S slope with acid outcrops along road, on *Xanthoparmelia conspersa*, 43°3.5'N, 6°23'W, 1450 m, 9.vii.2001, P. & B. v.d. Boom 27105 (hb. van den Boom); SW Oviedo, P.N. Somiedo, ESE of Pola de Somiedo, S of Vallar de Vildas, path to Braña la Pornacal, on *Xanthoparmelia* on horizontal wall, 43°5.5'N, 6°20.2'W, 1050 m, 7.vii.2001, P. & B. v.d. Boom 26951 (hb. van den Boom).

***Phacopsis oxyspora* (Tul.) Triebel & Rambold**

NOTES. – The specimens cited below represent *Phacopsis oxyspora* s. str., which occurs on members of *Parmelia* s.l. in several provinces of Spain. We here add several new localities.

*Specimens examined.* – **SPAIN. CÁDIZ:** W of Grazalema, Parc Natural ‘Sierra de Grazalema’, trail 2 km W of Grazalema, Pto. Boyar (starting point) to Benaocaz, “Ruta Salto del Cabrero”, 36°45.73'N, 5°20.8'W, 850 m, 2011, on *Parmelia* s.l. on *Crataegus*, P. & B. v.d. Boom 45995 (hb. van den Boom). **LLEIDA:** WNW of Bellver de Cerdanya, NNW of Martinet, Ref. Cap de Pla del Rec, on *Parmelia saxatilis* on granite, 42°25.9'N, 1°40.0'E, 1940 m, 12.viii.1998, P. v.d. Boom 21505 (hb. van den Boom). **SORIA:** Almarza, Santos Nuevos hermitage, on *Parmelia sulcata* on *Quercus pyrenaica*, 1300 m, 26.ix.1998, J. Etayo 16262 (hb. Etayo).

***Phacothecium varium* (Tul.) Trevis.**

(=*Opegrapha physciaria* (Nyl.) D. Hawksw. & Coppins)

NOTES. – There are many records of this species from Spain, but only a single record from Portugal (Hafellner 2009a, Llimona & Hladun 2001). We here add two new reports from Spain.

*Specimens examined.* – **SPAIN. VALENCIA:** SSE of Valencia, SSE of Xàbia, Cap de la Nau, near lighthouse, some *Pinus* trees, mixed shrubs (*Juniperus*, *Olea*, *Pistacia*) and calcareous outcrops, on *Xanthoria parietina*, on *Olea*, 38°44.0'N, 0°13.7'E, 35 m, 15.vi.2009, P. & B. v.d. Boom 43207 (hb. van den Boom); SSE of Valencia, NE of Xàbia, S of Cap de Sant Antonio, Cala Tangó, SE slope with mixed forest, including *Pistacia*, *Pinus* and calcareous outcrops, on *X. parietina*, on *Pistacia*, 38°48.0'N, 0°11.3'E, 30 m, 15.vii.2009, P. & B. v.d. Boom 43222 (hb. van den Boom).

***Phaeospora everniae* Etayo & van den Boom, sp. nov.**

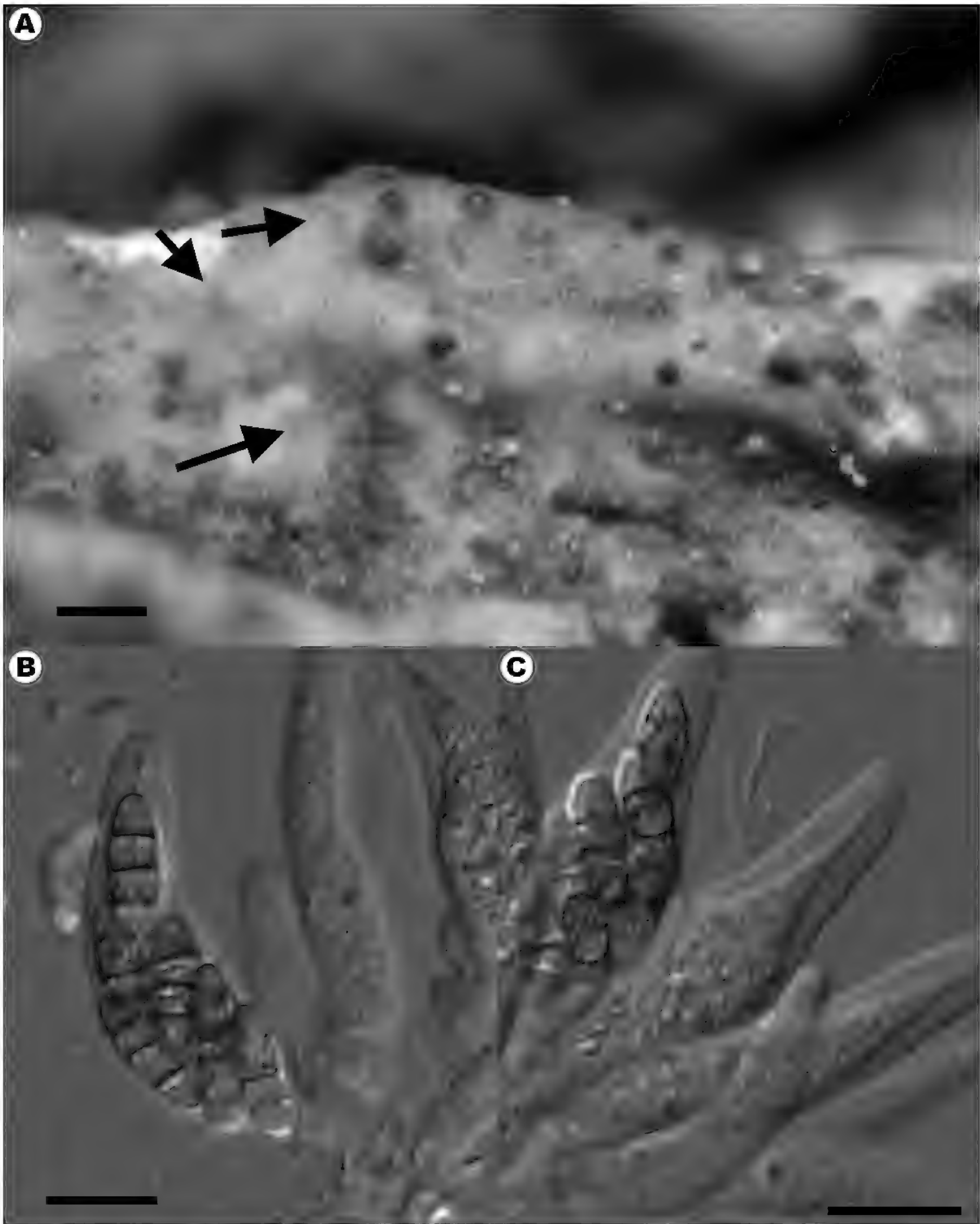
Mycobank #803959.

**FIGURE 1.**

DIAGNOSIS. – Lichenicolous fungus immersed in the thallus of *Evernia prunastri*. Ascomata 70–120 µm diam.; asci 8-spored; ascospores (2–)3-septate, brown, (11–)12–15(–16) × 4–5 µm, with many small oil guttules.

**TYPE: SPAIN. SALAMANCA:** S of Salamanca, Parc Natural Sierra de Francia, Miranda del Castañar, oak forest, on *Evernia prunastri* on *Quercus pyrenaica*, 40°28.5'N, 6°0.0'W, 610 m, 13.vi.2011, P. & B. van den Boom 46052 (BCN!, holotype; hb. van den Boom!, hb. Etayo!, isotypes).

DESCRIPTION. – Ascomata dispersed but abundant in dead thalli of *Evernia prunastri*, black, subsphaerical, immersed but finally erumpent only in the ostiolar zone, 70–120 µm diam. Vegetative hyphae immersed, brownish, septate, branched, 1–3 µm wide, thin walled. Exciple brown, 8–10 µm thick, composed of several layers of polygonal cells, 4–8 µm diam., internally hyaline, externally with a thin, dark wall, lower part covered with numerous elongate vegetative hyphae. Periphyses short, simple to 1-septate around the ostiole, 2–3 µm wide. Hymenium I+ red, KI+ blue (especially in the basal parts), without paraphyses. Asci bitunicate, wall apically thickened, obclaviform, (6–)8-spored, 50–60 × 9–13 µm, I–, KI–,



**Figure 1**, *Phaeospora everniae* (all from hb. Etayo 27833). A, habitus of black perithecia (the arrows denote perithecia of *Pronectria casaressii* also living on the sample). B and C, asci. Scales: A = 200  $\mu\text{m}$ ; B and C = 10  $\mu\text{m}$ .

except the KI+ orange epiplasm. Ascospores biserially arranged, ellipsoid, with obtuse apices, soon light grey to brownish inside the asci, without perispore, (2–)3-septate, septa very thin and sometimes with a small torus, not or slightly constricted at the septa, with many small oil guttules, (11–)12–15(–16) × 4–5 µm.

HOST. – On dead thallus of *Evernia prunastri*, in brown patches probably induced by the infection.

DISTRIBUTION. – So far, the new species is known from three provinces in Spain: Málaga, Navarra and Salamanca.

NOTES. – There are relatively few species of *Phaeospora* that are likely to be confused with the new taxon. The recently described *P. squamarinae* Etayo (Etayo 2010) has darker ascospores with a thicker central septum, that are smaller in size ((8–)9–11(–13) × 3.5–4.5(–5) µm) and ascomata which are dispersed on black spots of the host lichen. *Phaeospora arctica* Horáková & Alstrup, which grows on *Arctocetraria andrejevii* differs in having 6-spored asci and larger ascospores (15.5–18.5 × 5.5–6.5 µm) (Horáková & Alstrup 1994). *Phaeospora peltigericola* D. Hawksw. is similar in ascospore size but ascomata are smaller (50–75(–100) µm), it occurs on a different host (*Peltigera*), and the infection induces a greyish discoloration in the host (Hawksworth 1980).

Another similar species is *Leptosphaeria ramalinae* (Desm.) Sacc., which typically lives on *Ramalina*, although we have found similar material, not yet published, on *Evernia prunastri*. That species differs in having much larger ascomata, cylindrical asci, abundant hamathecial hyphae, and uniseriate, yellow-brown, clearly ornamentated, verruculose-granulose ascospores.

*Phaeospora everniae* was already recognized by Etayo (1998) as growing on *Evernia* together with *Pronectria casaresii* Etayo (note the latter can be seen as orange perithecia in figure 1). In Málaga and Navarra the new species also occurs with several other lichenicolous fungi such as *Lichenocodium erodens*, *Unguiculariopsis lettaui* and two other unidentified species. The new species may be saprophytic, because it appears even in the more degraded zones of the host thallus.

*Additional specimens examined:* **SPAIN. MÁLAGA:** Ronda, S<sup>a</sup> de las Nieves, 2 km before Cortijo de los Quejigales, 1050 m, 1994, on *Evernia prunastri* on *Quercus rotundifolia*, J. Etayo 14343 (hb. Etayo); South of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, 36°57.5'N, 4°32.5'W, 1200 m, 2011, on *E. prunastri*, P. & B. v.d. Boom 45956 (hb. van den Boom). **NAVARRA:** Unzué, Peña de Unzué, oak forest near the top, 42°39.4'N, 1°36.9'W, 900 m, 2012, on *E. prunastri*, on *Q. rotundifolia*, J. Etayo 27833 (hb. Etayo).

### ***Phoma grumantiana* Zhurb. & Diederich**

NOTES. – This species has previously been reported from Svalbard, North America (Diederich et al. 2007) and Luxembourg (Diederich et al. 2009). Here we provide the first report from the Iberian Peninsula.

*Specimen examined.* – **SPAIN. MÁLAGA:** SW of Antequera, Parc Natural ‘Desfiladero de los Gaitanes’, NE of Ardales, *Pinus* forest and calcareous outcrops, on *Cladonia*, on limestone, 36°55.9'N, 4°48.0'W, 390 m, 2011, P. & B. v.d. Boom 45972 (hb. van den Boom).

### ***Polycoccum evae* Calatayud & V.J. Rico**

NOTES. – In Spain, *Polycoccum evae* is known from Madrid and Girona (Atienza et al. 2003, Calatayud & Rico 1995), in the latter province from sea level to 2000 meters altitude. We here report a new locality.

*Specimen examined.* – **SPAIN. GIRONA:** 1.3 km NE of Meranges, 0.5 km further from crossing to Maljniu/Feixa, on *Dimeleaena oreina* on outcrop on S sloping *Pinus* forest, 42°27.3'N, 1°48.0'E, 2000 m, 14.viii.1998, P. v.d. Boom 21595 (hb. van den Boom).



***Polycoccum ibericum* Etayo & van den Boom sp. nov.**

Mycobank #803960.

**FIGURE 2.**

DIAGNOSIS. – Lichenicolous fungus, immersed in the thallus of a corticolous unknown *Rinodina* sp., similar to *Polycoccum rinodinae* van den Boom, but differing in smaller asci of  $38\text{--}50 \times 10\text{--}12\ \mu\text{m}$ , smaller ascospores of  $9.5\text{--}12.5 \times 4\text{--}5(-5.5)\ \mu\text{m}$ , inducing scattered, small, slightly wart-like galls on the thallus of the host, without producing necrosis or bleaching.

**TYPE: SPAIN. HUELVA:** S<sup>a</sup> de Aracena y Picos de Aroche, road from Aracena to Castañuelo, on *Rinodina* sp. on *Castanea*, 37°54.74'N, 6°34.7'W, 710 m, 12.ix.2007, P. & B. van den Boom 38540 (BCN!, holotype; hb. Etayo!, isotype).

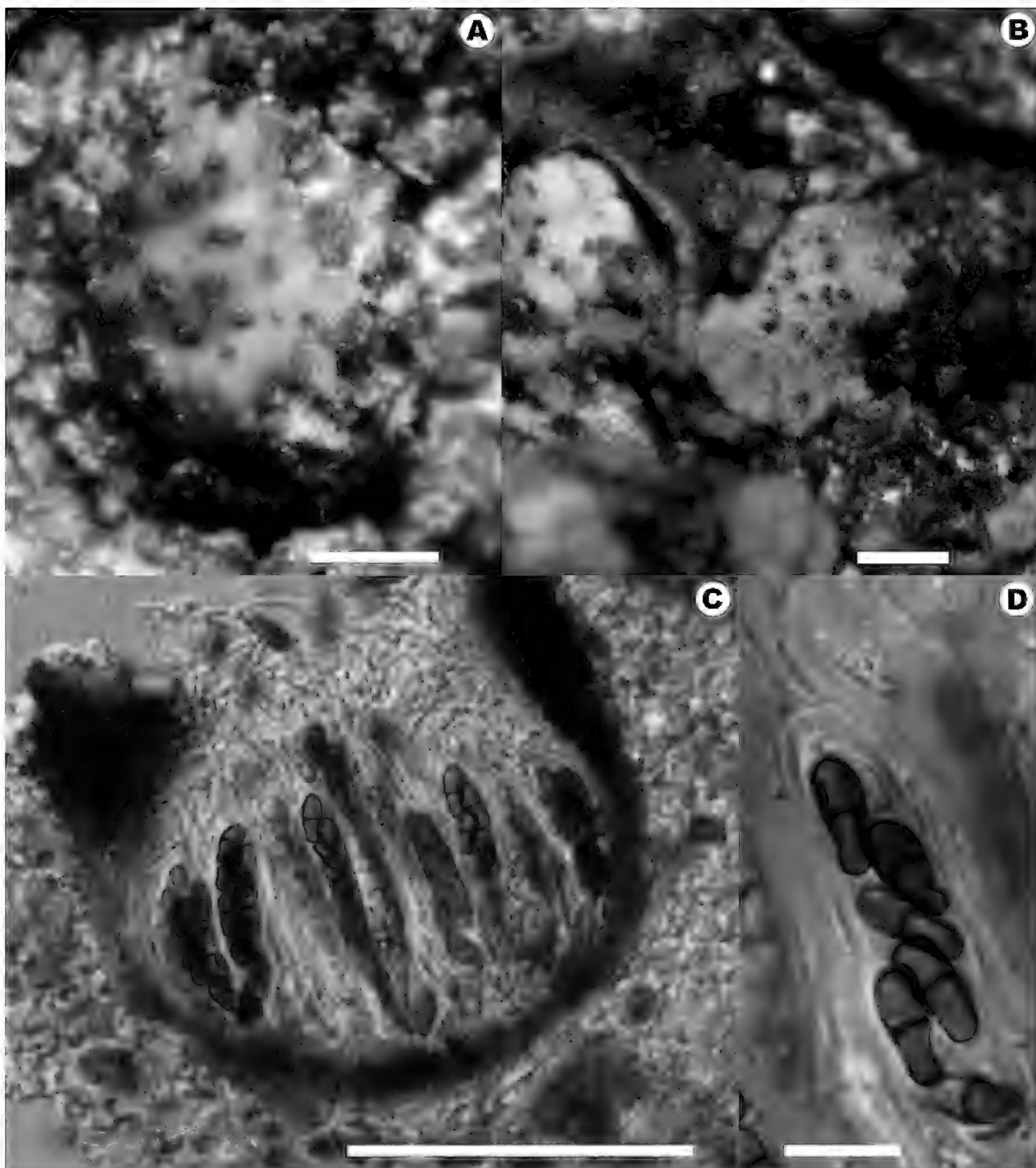
DESCRIPTION. – Ascomata regularly dispersed in the small squamules of the host, immersed, only visible by the black ostiole, subglobose, very small,  $50\text{--}90\ \mu\text{m}$  diam., inducing small semiglobose galls on the thallus of *Rinodina* sp. Exciple hyaline to light brownish below, ca.  $5\ \mu\text{m}$  thick, and reddish to dark brown in the upper part that is thickened up to  $15\ \mu\text{m}$  thick, composed of several layers of cells forming a paraplectenchymatic structure. Hymenial gelatine hyaline, I–. Pseudoparaphyses abundant, septate, simple to branched and anastomosing, ca.  $1.5\text{--}2\ \mu\text{m}$  wide. Asci abundant, bitunicate, wall apically thickened, claviform to subcylindric, 8-spored,  $38\text{--}50 \times 10\text{--}12\ \mu\text{m}$ . Ascospores biseriately or irregularly arranged, ellipsoid, lower cell smaller than upper one, brown, 1-septate, without a perispore but with a verruculose surface, with one large or two smaller oil guttules in each cell,  $9.5\text{--}12.5 \times 4\text{--}5(-5.5)\ \mu\text{m}$ . Conidiomata not observed.

HOST. – On the thallus of an unknown, corticolous *Rinodina* sp. (pers. comm. M. Giralt) with scattered sorediate squamules, very similar to those of *Caloplaca obscurella*. The species induces slight galls but does not visibly damage the host.

DISTRIBUTION. – *Polycoccum ibericum* is known from a scattered localities in western Spain and eastern Portugal.

NOTES. – The most distinctive characters of *Polycoccum ibericum* is its capacity to induce small thalline galls on the thin crustaceous pale brown thallus of corticolous *Rinodina* species and the relatively small size of its structures. *Polycoccum rinodinae* van den Boom, recently described from the Canary Islands (van den Boom 2010), occurs on saxicolous *Rinodina* species such as *R. beccariana* Bagl. and *R. etayoi* Giralt & van den Boom rather than on corticolous species. That species differs from *P. ibericum* in its larger ascomata (up to  $125\ \mu\text{m}$  in diameter), larger asci ( $50\text{--}80 \times 12\text{--}17\ \mu\text{m}$ ) and coarsely verruculose spores when mature that measure  $16\text{--}20 \times 5\text{--}6.5(-7)\ \mu\text{m}$ . Several other species of *Polycoccum* grow on members of the Physciaceae. Of these *P. alboatrum* (Vouaux) Etayo, *P. nigrosporum* Etayo and *P. epizoharyi* Calatayud & V. Atienza, all grow on crustose members of the family, but they have larger ascospores ( $14\text{--}18 \times 6\text{--}8\ \mu\text{m}$ ,  $13.5\text{--}16 \times 8\text{--}9.5\ \mu\text{m}$  and  $14\text{--}18 \times 7\text{--}10\ \mu\text{m}$  respectively) and the hosts are all from different genera (*Diplotomma* and *Buellia*). *Polycoccum atrostriatae* van den Boom and *P. pulvinatum* (Eitner) R. Sant. are two different species also from *Physcia*, a foliose genus in the Physciaceae. The latter taxon has much larger ascospores ( $(14\text{--})18\text{--}21(-23) \times (6\text{--})7.5\text{--}8.5(-9)\ \mu\text{m}$ ), than the new species. The former taxon has somewhat smaller ascospores which are obliquely monostichously arranged in asci that are  $45\text{--}60 \times 8\text{--}10\ \mu\text{m}$  in size (van den Boom 2012). *Polycoccum evae*, which grows on *Dimelaena oreina* has larger ascospores, which are coarsely verruculose and the ascomata are also larger.

Some further species of *Polycoccum* with relatively small ascospores also known from Spain are *P. peltigeriae* (Fuckel) Vězda, *P. arnoldii* (Hepp) D. Hawksw. and *P. microcarpum* Diederich & Etayo. The first has monostichously arranged ascospores that are  $13\text{--}15 \times (4\text{--})5\text{--}6\ \mu\text{m}$  in size and is only known from *Peltigera thalli* (Atienza et al. 2003). *Polycoccum arnoldii* has ascospores  $9\text{--}11.5(-13) \times 4.5\text{--}6.5(-7)\ \mu\text{m}$  in size, ascomata approximately  $80\ \mu\text{m}$  in diameter, does not form galls on the host, and grows on crustose lichens from different genera such as *Diploschistes* and *Lecania*, although also reported from *Rhizocarpon* (Atienza et al. 2003). In *Polycoccum microcarpum* the ascomata are black and  $30\text{--}60(-100)\ \mu\text{m}$  in diameter, aggregated in groups of  $20\text{--}80$  and immersed in convex galls on the squamules of *Cladonia cervicornis*, and the ascospores are  $12\text{--}14.5 \times 4.5\text{--}7\ \mu\text{m}$  in size (Etayo & Diederich 1998).



**Figure 2,** *Polycoccum ibericum* (all from the holotype). A and B, habitus. C, perithecium in trasverse section. D = asci. Scales: A and B = 0.2 mm; C = 100 µm; D = 10 µm.

*Additional specimens examined:* **SPAIN. HUELVA:** W of Aracena, NNW of Cortegana, Sierra de La Cigüeña, road between La Corte and Las Cefiñas, orchard with *Quercus ilex* on W slope, on *Rinodina* on *Q. ilex*, 560 m, 2007, *P. & B. v.d. Boom* 38826 (hb. van den Boom); W of Aracena, SE of Cortegana, Sierra de San Cristóbal, W slope of San Cristóbal, trail from Almonaster la Real to Pto. de las Encrucijadas, mixed trees in forest with old walls of stones, on *Rinodina* on *Q. ilex*, 750 m, 2007, *P. & B. v.d. Boom* 38824 (hb. van den Boom). **PORTUGAL. ALENTEJO:** ENE of Beja, NNE of Serpa, ca. 2 km N of Moura, along road N 386, *Q. ilex* orchard, on *Rinodina* on *Q. ilex*, 160 m, 2007, *P. & B. v.d. Boom* 38666 (hb. van den Boom); SE of Beja, SSE of Serpa, along road to Mertola, ca. 3 km S of Santa Iria, orchard with young *Q. suber* and mature *Q. ilex* trees, on *Rinodina* on *Q. ilex*, 125 m, 2007, *P. & B. v.d. Boom* 38692 (hb. van den Boom).

***Polycoccum microsticticum* (Leight.) Arnold**

NOTES. – Although reported as occurring on different host genera such as *Acarospora* subgen. *Xanthothallia*, *Buellia* and *Rhizocarpon* (Hawksworth & Diederich 1988), or *Ionaspis* (Alstrup & Hawksworth 1990, Santesson et al. 2004), the type of *Polycoccum microsticticum* is actually on *Acarospora* subgen. *Phaeothallia* and a collection from Spain that was made on the same host subgenus was reported by Atienza et al. (2003). Here we report the species for the first time from the host genus *Dimelaena*.

*Specimens examined.* – **SPAIN. ALMERÍA:** ESE of Almería, Sierra del Cabo de Gata, E Cabo de Gata, S of Rodalquilar, near Cala de los Toros, on *Dimelaena radiata* on gently sloping rock, 36°49.46'N, 2°2.52'W, 90 m, 6.ix.2007, *P. & B. v.d. Boom* 38435 (hb. van den Boom); Sierra del Cabo de Gata, SW of San José, path between Casa Mónsul to Torre de Vela Blanca, on *Dimelaena radiata* on horizontal exposed rock, 36°43.85'N, 2°10.14'W, 75 m, 2007, *P. & B. v.d. Boom* 38412 (hb. van den Boom).

***Polycoccum pulvinatum* (Eitner) R. Sant.**

NOTES. – Several references to Spanish records of this species are cited in Hladun and Llimona (2002-2007). We here add several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, ESE of Pola de Somiedo, S of Vallar de Vildas, path to Braña la Pornacal, on *Physcia* on wall, 43°5.5'N, 6°20.2'W, 1050 m, 7.vi.2001, *P. & B. v.d. Boom* 26949 (hb. van den Boom). **SORIA:** Yanguas, on rockface near the church in the village, on *Physcia caesia* on rock, 1000 m, 16.v.1999, *J. Etayo* 16076 (hb. Etayo); Abejar, sabinar of *Juniperus thurifera*, on *Physcia biziana*, 1100 m, 27.ix.1998, *J. Etayo* 16988 (hb. Etayo).

***Polycoccum umbilicariae* (Linds.) D. Hawksw.**

NOTES. – Lindsay (1869) found a fungus growing on *Lasallia pustulata* from Norway and named it *Microthelia umbilicariae* Linds. In the protologue he wrote “paraphyses very delicate and indistinct, as in *Verrucaria*” and “hymenial gelatine is violet with iodine”, suggesting that it does not have paraphyses, but only small superficial structures resulting from empty asci. Drawings associated with the protologue could be interpreted in this way because Lindsay drew several vertical lines between the asci without clearly drawing paraphyses. He also referred to the ascospores as initially being hyaline and eventually becoming brown (“contents of young asci colourless, gradually assuming a brown tint as the protoplasm becomes distinctly partitioned into sporidia, they are 1(–2)-septate oval or broadly ellipsoid”).

Hawksworth (1985) studied the type of *Microthelia umbilicariae* giving the ascospore measurements as 13.5–15 × (6–)6.5–7.5 µm. He stated that cellular paraphyses could be demonstrated in vertical section but were difficult to discern in squash preparations, and so made the combination into *Polycoccum*.

Our study of a recent sample growing on *Lasallia pustulata* from Spain agrees with the characteristics of *M. umbilicariae* and with the drawings in Lindsay (1869). But the specimen shows several interesting details: 1) an I+ red, KI+ blue hymenium without hamathecial filaments, only remnants of ruptured ascus walls, 2) widely clavate asci with walls thickened in the upper portions, 55–64 × 18–25 µm in size and with (4–)8 spores; 3) ascospores that are brown, 1-septate, ellipsoid, rounded at the ends, not constricted at the septum, smooth walled, halonate, widely ellipsoid, and 11–14 × 6–8 µm in size; and 4) while in the asci the ascospores are hyaline or pale brown and simple, only producing the median septum in an advanced stage. Therefore, in our opinion, this species clearly belongs to *Endococcus*. We refrain from making the combination pending study of the type of *M. umbilicariae*. The specimen cited below appears to be the first Iberian record of the species.

*Specimen examined.* – **SPAIN. CÁCERES:** 41 km ENE of Plasencia, N of Jarandilla, 1–3 km N of Guijo de Sta. Bárbara, along path E of river Jaranda, on *Lasallia pustulata* on acid rock on SW slope, 1400 m, 1989, *P. v.d. Boom* 8869 (hb. van den Boom).

***Pronectria casaesii* Etayo**

NOTES. – This species was described by Etayo (1998) as growing on *Evernia prunastri* from southern Spain. Subsequent to its description no other reports of this very inconspicuous species have been published. We found a well developed population in a humid *Quercus rotundifolia* woodland in northern Spain. The perithecial colour of the type was described as yellowish but in the newly discovered population the colour was pinkish in fresh material (see figure 1). The asci and ascospores of the new material fit well with those given in the original description.

*Specimen examined.* – **SPAIN. NAVARRA:** Unzué, Peña de Unzué, oak forest (*Quercus rotundifolia*) near the top, 42°39.4'N, 1°36.9'W, 900 m, 2012, on *Evernia prunastri*, *J. Etayo* 27833 (hb. Etayo).

***Pronectria oligospora* Lowen & Rogerson var. *octospora* Etayo**

NOTES. – The type specimen of this variety is from northern Spain (Etayo 1998) and it has been reported from other European countries such as Belgium, France, Germany and the Netherlands (Brackel 2010, Coste 2009, Sérusiaux et al. 2003, van den Boom & Masselink 1999, van den Boom & van den Boom 2006). We here add a new locality.

*Specimen examined.* – **SPAIN. HUELVA:** W of Aracena, SE of Cortegana, S<sup>a</sup> de San Cristóbal, W slope of S. Cristóbal, trail from Almonaster La Real to Pto. de las Encrucijadas, on *Punctelia subrudecta* on young *Quercus ilex*, 37°52.7'N, 6°46.95'W, 750 m, 13.ix.2007, *P. & B. v.d. Boom* 38611 (hb. van den Boom).

***Pronectria tinctoria* (Fuckel) Lowen**

NOTES. – For notes on the relationship between *Pronectria tinctoria* and *P. santessonii* (Lowen & D. Hawksw.) Lowen, see Etayo (2010). We here document an additional locality.

*Specimen examined.* – **SPAIN. MÁLAGA:** S of Antequera, Parc Natural El Torcal, limestones, with shrubs and small trees, on an unidentified shrub on *Anaptychia*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, *P. & B. v.d. Boom* 45957 (hb. van den Boom).

***Reconditella physconiarum* Hafellner & Matzer**

NOTES. – This species is usually collected on the lobe margins of members of the genus *Physconia*. Our specimen matches well the published descriptions of *Reconditella physconiarum* (Matzer & Hafellner 1990); however it was found growing on the surface of the lobes (vs. the margins) of *Phaeophyscia orbicularis*. The specimen was also infected by *Taeniolella phaeophysciae*, which like *R. physconiarum* is also known to occur on *Physconia*, and also by *Tremella phaeophysciae*.

*Specimen examined.* – **SPAIN. CÁDIZ:** Grazalema, Parc Natural “S<sup>a</sup> de Grazalema”, just E edge of village, on *Phaeophyscia orbicularis* on *Cupressus* along the road, 36°45.7'N, 5°20.8'W, 850 m, 2011, *P. & B. v.d. Boom* 46005 (hb. van den Boom).

***Rhizocarpon epispilum* (Nyl.) Zahlbr.**

NOTES. – Notes on this Mediterranean species have been published previously by Poelt (1990). It has been reported from Spain before, especially from the eastern part of the country (Llimona & Hladun 2001). We here report an additional locality.

*Specimen examined.* – **SPAIN. SALAMANCA:** SW of Salamanca, Parc Natural ‘Sierra de la Peña de Francia’, on the top (Peña de Francia), on acidic outcrops in open area, on *Pertusaria*, 40°30.8'N, 6°10.2'W, 1700 m, 2011, *P. & B. v.d. Boom* 46076 (hb. van den Boom).

***Rimularia insularis* (Nyl.) Rambold & Hertel**

NOTES. – This seems to be a very common species on the Iberian Peninsula, where it always grows on *Lecanora rupicola*. We here add several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, P.N. Somiedo, S of Pola de Somiedo, 4.5 km N of Puerto Somiedo, on *Lecanora rupicola* on acid outcrops along road, 43°3.5'N, 6°2.3'W, 1450 m, 9.vii.2001, *P. & B. v.d. Boom* 27104 (hb. van den Boom). **GIRONA:** 1.3 km NE of



Meranges, 0.5 km further from crossing to Maljniu/Feixa, on *L. rupicola* on outcrop on vertical rock, 42°27.3'N, 1°48.0'E, 2000 m, 14.viii.1998, *P. v.d. Boom* 21571 (hb. van den Boom). **LLEIDA:** SSE of Bellver de Cerdanya, between Flans de Bor and Ref. dels Cortals de L'ingla, on *L. rupicola* on vertical sunny rock, 42°18.8'N, 1°48.6'E, 1700 m, 10.viii.1998, *P. v.d. Boom* 21348 (hb. van den Boom). **NAVARRA:** Fustiñana, Reserva Natural Caídas de la Negra y Juego de Pelota, on *L. rupicola* on sandstone, ca. 600 m, 26.ii.1995, *J. Etayo* 15121 (hb. Etayo). **SORIA:** Gallinero, Sierra de Montes Claros, *Q. pyrenaica* forest with *Fagus* and *Ilex*, on *L. rupicola* on sandstone, 41°90'N, 2°20'W, 1400 m, 22.xi.1998, *J. Etayo* 17119 (hb. Etayo), *J. Etayo* 17134 (hb. Etayo), *J. Etayo* 17164 (hb. Etayo).

***Rinodina obnascens* (Nyl.) H. Olivier**

NOTES. – Giralt (2001) reported this blastidiate species from several provinces of Spain but not from Asturias. Here we extend its range to include that province.

*Specimen examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, P.N. Somiedo, SW of Pola de Somiedo, S of Vallar de Vildas, Braña la Pornacal, on *Aspicila* on outcrop in open field, 43°4.3'N, 6°19.5'W, 1100 m, 7.vii.2001, *P. & B. v.d. Boom* 26952 (hb. van den Boom).

***Sarcopyrenia bacillosa* (Nyl. ex Hasse) Nav.-Ros. & Hladun**  
(= *Hassea bacillosa* (Nyl.) Zahlbr.)

NOTES. – This is the first European record of this species which has acicular, simple ascospores. Navarro-Rosinés & Hladun (2004) reported that the type material of this species grew on a crustose lichen with *Nostoc* as photobiont. However, Knudsen and Lendemer (2006) reported it from *Acarospora socialis*, a crustose, green alga lichen. Although Navarro-Rosinés and Hladun (2004) reported the type as having ascospores (19–)23–34(–40) × 1.5–2.5 µm in size, the Spanish sample has longer ascospores (37–48 × 1.5–2 µm). The European material was found growing on *Gloeoheppia*, a lichen with a chroococcoid cyanobacterium as photobiont.

*Specimen examined.* – **SPAIN. MURCIA:** WSW of Cartagena, road from Mazarrón to Águilas, S of Ramonete, on *Gloeoheppia turgida* on S sloping rock, 37°32.3'N, 1°29.4'W, 225 m, 14.vii.2005, *P. & B. v.d. Boom* 34830 (hb. van den Boom).

***Sclerococcum leuckertii* Diederich & P. Scholz**

NOTES. – This species was not reported from the study area by Etayo and Calatayud (1998) and thus this appears to be the first Iberian record. It is a parasitic hyphomycete that occurs on *Buellia aethalea*, and has previously been reported from the Czech Republic (Kocourková 2000), Denmark, Germany, Sweden (Diederich & Scholz 1995) and France (Roux et al. 2011).

*Specimens examined.* – **SPAIN. SORIA:** Gallinero, Sierra de Montes Claros, areniscas en rebollar, on *Buellia aethalea*, 41°9'N, 2°2'W, 1400 m, 22.xi.1998, *J. Etayo* 17137, 17163 (hb. Etayo).

***Sclerococcum sphaerale* (Ach.) Fr.**

NOTES. – Many Iberian records of this species were published by Hladun and Llimona (2002–2007). We here report several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, P.N. Somiedo, S of Pola de Somiedo, 4.5 km N of Puerto Somiedo, on *Pertusaria corallina* on acid outcrops along road, 43°3.5'N, 6°2.3'W, 1450 m, 9.vii.2001, *P. & B. v.d. Boom* 27122 (hb. van den Boom). **NAVARRA:** valle del Baztán, puerto de Izpegui, near the top, rockface between *Fagus* entre hayas, on *P. corallina*, ca. 700 m, 1998, *J. Etayo* 14247 (hb. Etayo); valle del Baztán, Legate, Peña de Aracán, on *P. corallina* on sandstone, 1993, *J. Etayo* 14384 (hb. Etayo).

***Scoliciosporum intrusum* (Th. Fr.) Hafellner**

(= *Carbonea intrusa* (Th. Fr.) Rambold & Triebel)

NOTES. – *Scoliciosporum intrusum* is usually reported as occurring on saxicolous lichens, however, we found two samples on epiphytic *Pertusaria albescens*. It was recently reported from Aragón (Etayo 2010). We here report two new localities.

*Specimens examined.* – **SPAIN. NAVARRA:** Sierra de Illón, monte Belbún, Navascués, 2 km from Castillonuevo, on *Pertusaria albescens* on *Fagus*, ca. 1250 m, 1994, *J. Etayo* 14485 (hb. Etayo).

**PALENCIA:** La Cruz, Velilla del Río Carrión, on *P. albescens* on *Juniperus thurifera*, iv.2001, *J. Etayo 14484* (hb. Etayo).

***Skyttea gossypina* Etayo**

NOTES. – This species, recently described by Etayo (2010), is very characteristic because of its long, hyaline excipular hairs. After studying the new sample we can add to the description that the ascomata are much more variable in size, reaching 300 µm in diameter, and also that the ascospores may be longer ( $4.5-8 \times 2.5-3$  µm). This is the second known record of this species that occurs on *Phlyctis argena*.

*Specimen examined.* – **SPAIN. MÁLAGA:** S<sup>a</sup> de Antequera, Parc Natural El Torcal, karst area with shrubs and small trees on *Phlyctis argena* on *Crataegus*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, *P. & B. v.d. Boom 45958* (hb. van den Boom).

***Sphaerellothecium atryneae* (Arnold) Cl. Roux & Triebel**

NOTES. – The specimen cited below was found growing on the apothecia of *Lecanora rupicola*, together with *Intralichen christiansenii* (D. Hawksw.) D. Hawksw. & M.S. Cole and *Lichenocodium lecanorae* (Jaap) D. Hawksw. The species was first reported from the Iberian Peninsula by Etayo (2010) from Zaragoza, and here provide the second report for the region.

*Specimen examined.* – **SPAIN. NAVARRA:** valle del Baztán, Legate, peña del Aracán, on *Lecanora rupicola* on sandstone in the summit, 870 m, 21.vii.1993, *O. Breuss & J. Etayo 14414* (hb. Etayo).

***Sphaerellothecium cladoniae* (Alstrup & Zhurb.) Hafellner**

NOTES. – We here report two new localities of this common species, although it has not been reported frequently in the Iberian Peninsula, at least under this name.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 5.5 km ESE Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on *Cladonia pyxidata*, 43°2.7'N, 6°8.6'W, 1570 m, 8.vii.2001, *P. & B. v.d. Boom 27085* (hb. van den Boom). **PALENCIA:** Aguilar de Campoó, castle, on *Cladonia* cf. *chlorophaea*, on limestone fissures, 1000 m, 19.iv.2001, *J. Etayo 18092 & E. Ros* (hb. Etayo).

***Sphinctrina leucopoda* Nyl.**

NOTES. – Hladun and Llimona (2002-2007) reported several collections of this species from Spain. We here add a new locality.

*Specimen examined.* – **SPAIN. SALAMANCA:** SW of Salamanca, Parc Natural 'Sierra de la Peña de Francia', 1 km E of La Alberca, Castaño, open forest with mature *Quercus pyrenaica* trees, and one very big *Castanea sativa* tree, on *Pertusaria* on *Castanea*, 40°29.41'N, 6°05.7'W, 1030 m, 2011, *P. & B. v.d. Boom 46095* (hb. van den Boom).

***Stigmidium cerinae* Cl. Roux & Triebel**

NOTES. – Roux and Triebel (1994) described this species from scattered localities in Europe (Austria, Germany, Italy and Switzerland). Later it was reported from Belgium (van den Boom et al. 1998), Russia (Zhurbenko 2004) and Sweden (Santesson et al. 2004). This is first report of the species from Spain.

*Specimen examined.* – **SPAIN. ASTURIAS:** SW Oviedo, P.N. Somiedo, SE Pola de Somiedo, 5.5 km ESE Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on apothecia of *Caloplaca stillicidiorum*, 43°2.7'N, 6°8.6'W, 1570 m, 8.vii.2001, *P. & B. v.d. Boom 27085* (hb. van den Boom).

***Stigmidium congestum* (Körb.) Triebel**

NOTES. – Several Spanish records were published by Hladun and Llimona (2002-2007). We report two additional localities here.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, S of Grado, S of Proaza, W of Teverga, along road to Villanueva, on corticolous *Lecanora* on *Juglans*, 43°9.5'N, 6°7.1'W, 800 m, 4.vii.2001, *P. & B. v.d. Boom 26831* (hb. van den Boom). **SORIA:** Sabinar de la Cueva del Agua, Villaciervos, on *Lecanora chlarotera* on *Juniperus thurifera*, ca. 1000 m, 14.iii.1997, *J. Etayo 14975* (hb. Etayo).

***Stigmidium gyrophorarum* (Arnold) D. Hawksw.**

NOTES. – Roux and Triebel (1994) distinguished the holotype of this species from an undescribed *Sphaerellothecium* species also growing on *Umbilicaria* at the same locality, by its having ascomata 90–120 × 80–92 µm in size, and at first hyaline, later brown, ascospores measuring 13–16 × 5–7 µm. These data are similar to those of our sample.

*Specimen examined.* – **SPAIN. SORIA:** Gallinero, Sierra de Montes Claros, on *Umbilicaria polyphylla* on sandstones below the *Quercus pyrenaica* forest, 41° 90'N, 2°20'W, 1400 m, 22.xi.1998, *J. Etayo* 17135 (hb. Etayo).

***Stigmidium lecidellae* Triebel, Cl. Roux & Le Coeur**

NOTES. – So far this species has been reported from the Iberian Peninsula from Aragón, Cataluña and Navarra (Etayo 2010). We here add a new locality.

*Specimen examined.* – **SPAIN. LA RIOJA:** Tierra de Cameros, Gallinero de Cameros, grove near stream, on *Lecidella elaeochroma* on a trunk, 1000 m, 11.iv.1996, *J. Etayo* 14282 (hb. Etayo).

***Stigmidium psorae* (Anzi) Hafellner**

NOTES. – Several Iberian reports of this species were published by Hladun and Llimona (2002–2007). Here we publish two additional reports.

*Specimens examined.* – **SPAIN. ALMERÍA:** N rim of Sierra Cabrera, W of Mojácar, W of Turre, near bridge over Río de Aguas, on *Psora decipiens* on horizontal soil with shrubs and *Chamaerops humilis*, 37°8.48'N, 1°55.97'W, 90 m, 5.ix.2007, *P. & B. v.d. Boom* 38370 (hb. van den Boom). **NAVARRA:** Peralta, S<sup>a</sup> de Peralta in the way to Andosilla, gypsiferous soil, near the road, on *P. decipiens* on soil, ca. 450 m, 12.iv.1998, *J. Etayo* 15136 (hb. Etayo).

***Stigmidium ramalinae* (Müll. Arg.) Etayo & Diederich**

NOTES. – According to Hladun and Llimona (2002–2007), this species was not known to occur on the Iberian Peninsula. Here we present the first report for the study area and for Spain.

*Specimen examined.* – **SPAIN. ALMERÍA:** Sierra del Cabo de Gata, SW of San José, path between Casa Mónsul to Torre de Vela Blanca, on *Ramalina rosacea* on N exposed vertical rock, 36°43.85'N, 2°10.14'W, 75 m, 6.ix.2007, *P. & B. v.d. Boom* 38411 (hb. van den Boom).

***Stigmidium squamarinicola* Calat. & Triebel**

NOTES. – Calatayud and Triebel (2003) reported this species from several regions in Spain, namely Andalucía, Madrid, Valencia and Navarra. Here we present the first record from Murcia province.

*Specimen examined.* – **SPAIN. MURCIA:** S of Cartagena, NE of El Puerto, La Azohia, near Torre Santa Elena, on *Squamarina lentigera* on N sloping soil, 37°32.9'N, 1°10.3'W, 110 m, 17.vi.2003, *P. & B. v.d. Boom* 30900 (hb. van den Boom).

***Stigmidium tabacinae* (Arnold) Triebel**

NOTES. – Several reports of this species from the Iberian Peninsula were published by Hladun and Llimona (2002–2007). Here we add several additional localities.

*Specimens examined.* – **SPAIN. LEÓN:** NW of León, P.N. San Emiliano, E of Sena de Luna, on *Toninia* sp. on soil, 42°55.1'N, 5°56.3'W, 1000 m, 9.vii.2001, *P. & B. v.d. Boom* 27126 (hb. van den Boom). **LLEIDA:** W of Bellver de Cerdanya, campsite, along stream, on *Toninia sedifolia* on calcareous outcrops, 42°22.6'N, 1°45.8'E, 1000 m, 12.viii.1998, *P. v.d. Boom* 21519 (hb. van den Boom). **MURCIA:** WSW of Cartagena, Serra de la Muela, N of Campillo de Adentro, E of road Cartagena to El Puerto, on *Toninia* sp. on N slope, 37°35.8'N, 1°8.3'W, 385 m, 16.vii.2003, *P. & B. v.d. Boom* 30871 (hb. van den Boom); WSW of Cartagena, 2 km S of Pinilla, on *Toninia sedifolia* on N sloping outcrops, 37°40.0'N, 1°17.0'W, 305 m, 16.vii.2005, *P. & B. v.d. Boom* 34860 (hb. van den Boom).

***Syzygospora physciacearum* Diederich**

Notes. – There are surprisingly few reports of this species from the Iberian Peninsula in Hladun and Llimona (2002–2007). Here we report two additional localities.

*Specimens examined.* – **SPAIN. HUELVA:** N of Aracena, S<sup>a</sup> de Aracena y Picos de Aroche, road from Aracena to Castañuelo, edge of old *Castanea* forest, on *Physcia adscendens* on *Quercus*, 37°54.74'N, 6°34.07'W, 710 m, 12.ix.2007, *P. & B. v.d. Boom* 38552 (hb. van den Boom). **NAVARRA:** Roncal, way

from hotel Zaltúa to the hermitage, trees on the way, on *Physcia aipolia* on branches, 750 m, 20.ix.1997, *J. Etayo* 14571 (hb. Etayo).

***Taeniolella beschiana* Diederich**

NOTES. – *Taeniolella beschiana* is a widely distributed species (Zhurbenko & Alstrup 2004), but the specimen reported here is only the second record from the Iberian Peninsula (Etayo 2002).

*Specimen examined.* – **SPAIN. ASTURIAS:** NW of Oviedo, 25 km W of Avilés, Cabo Vidio, N to W slope with outcrops along N coast, on *Cladonia* sp. on slope, 43°32.7'N, 6°14.3'W, 100 m, 5.vii.2001, *P. & B. v.d. Boom* 26838 (hb. van den Boom).

***Taeniolella phaeophysciae* D. Hawksw.**

NOTES. – This species was previously reported from Cataluña (Llimona & Hladun 2001) and Aragón (Etayo 2010). Here we considerably enlarge its known distribution in Spain.

*Specimens examined.* – **SPAIN. LLEIDA:** W of Bellver de Cerdanya, NNW of Martinet, 0.5 km N of Travesseres, on *Phaeophyscia orbicularis* on *Quercus pyrenaica*, 42°23'N, 1°41.3'E, 1275 m, 12.viii.1998, *P. v.d. Boom* 21514 (hb. van den Boom). **NAVARRA:** Sengáriz, on *Physconia distorta* on *Quercus faginea*, 42°39.9'N, 1°24'W, 700 m, 31.i.1987, *J. Etayo* 4126 (hb. Etayo); Iragui, oak forest of *Q. faginea* on slope, on *Physconia distorta*, 700 m, 10.iii.1996, *J. Etayo* 13788 (hb. Etayo), *J. Etayo* 13851 (hb. Etayo). **SORIA:** Gallinero, Sierra de Montes Claros, 41°9'N, 2°2'W, *Q. pyrenaica* forest with *Fagus* and *Ilex*, on *Physconia* on *Q. pyrenaica*, 1400 m, 22.ix.1998, *J. Etayo* 17127 (hb. Etayo); Capital, way around Duero river, way to S. Saturio, alder wood, on *Phaeophyscia orbicularis* on *Aesculus*, 900 m, 21.x.2001, *J. Etayo* 18367 (hb. Etayo). **TARRAGONA:** Baix Ebre, Roquetes, way to Ports de Beceite, 2 km crossroad to Monte Caro, on *Physcia aipolia* in oak forest on *Quercus ilex*, 1115 m, 13.vii.1995, *J. Etayo* 12968 (hb. Etayo).

***Teloggalla olivieri* (Vouaux) Nik. Hoffm. & Hafellner**

NOTES. – This species often occurs together with *Xanthoriicola physciae* on the thalli of *Xanthoria* species. *Teloggalla olivieri* usually occurs on the thallus of the host, while *Xanthoriicola physciae* is restricted to the apothecia. Etayo (2010) reported the species from Aragón where he considered it to be common. We add here several new localities.

*Specimens examined.* – **SPAIN. LLEIDA:** SW of Bellver de Cerdanya, 0.8 km S of Nas, path from manege to Mirador, on *Xanthoria parietina* on *Buxus*, 42°20.8'N, 1°44.5'E, 1300 m, 9.viii.1998, *P. v.d. Boom* 21335b (hb. van den Boom). **NAVARRA:** Iragui, *Quercus faginea* forest on slope with well developed Xanthorion, on *X. parietina* on *Quercus faginea*, 700 m, 10.iii.1996, *J. Etayo* 13808 (hb. Etayo). **SORIA:** Sabinar de la Cueva del Agua, Villaciervos, on *X. parietina* on *Juniperus thurifera*, ca. 1000 m, 14.iii.1997, *J. Etayo* 14972 (hb. Etayo).

***Toninia episema* (Nyl.) Timdal**

NOTES. – Many reports of this species from the Iberian Peninsula were published by Hladun and Llimona (2002-2007). We here add several new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, S of Grado, S of Proaza, along río Teverga, 1 km N of Teverga, on *Aspicilia calcarea* on limestone boulders, 43°10.9'N, 6°5.3'W, 800 m, 4.vii.2001, *P. & B. v.d. Boom* 26807 (hb. van den Boom); 35 km E of Cangas de Onís, 10 km W of Panes, 0.7 km S of Trescares, on *Aspicilia* on limestone, 250 m, 23.vii.1989, *P. v.d. Boom* 8917 (hb. van den Boom). **LLEIDA:** SW of Bellver de Cerdanya, 1.2 km S of Nas, path from manege to Mirador, on *A. calcarea* on calcareous outcrops, 42°20.7'N, 1°44.5'E, 1300 m, 9.viii.1998, *P. v.d. Boom* 21351 (hb. van den Boom). **MURCIA:** S of Cartagena, Cabo Tiñoso, near transmitter mast, on *A. calcarea* on N sloping rock, 37°33.1'N, 1°9.2'W, 370 m, 19.vii.2003, *P. & B. v.d. Boom* 30941 (hb. van den Boom). **NAVARRA:** Estella, Los Pinos, on *A. calcarea* on limestone, 31.iii.1991, *J. Etayo* 11142 (hb. Etayo). **VALENCIA:** SSE of Valencia, SSE of Xàbia, Cap de la Nau, near lighthouse, some *Pinus* trees, mixed shrubs (*Pistacia*, *Juniperus*) and calcareous outcrops, on *A. calcarea*, 38°44.0'N, 0°13.7'E, 35 m, 15.vi.2009, *P. v.d. Boom* 43202 (hb. van den Boom).

***Toninia subfuscae* (Arnold) Timdal**

NOTES. – Hladun and Llimona (2002-2007) reported several specimens of this species from Spain. Here we report an additional locality.



*Specimen examined.* – **SPAIN. MALLORCA:** between Cala D’or and Porto Colom, Cala Arsenau, on *Lecanora horiza* on *Juniperus phoenicea*, 20 m, 1997, P. & B. v.d. Boom 18490 (hb. van den Boom).

***Toninia verrucarioides* (Nyl.) Timdal**  
(= *T. kolax* Poelt)

NOTES. – Hladun and Llimona (2002-2007) published many reports of this species from the Iberian Peninsula. We here add two new localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** Picos de Europa, 7.5–10 km SE of Covadonga, path from Lago de la Ercina to Llaguella, on *Placynthium subradiatum* on limestone, on slope with scattered *Fagus* trees, 1250 m, 24.vii.1989, P. v.d. Boom 9006 (hb. van den Boom), on *Placynthium* cf. *nigrum*, P. v.d. Boom 8992 (hb. van den Boom). **NAVARRA:** Muguiro, limestone boulders at the end of the village near the old railway, on *Placynthium* on limestone, 550 m, 24.iii.1996, J. Etayo 13825 (hb. Etayo).

***Tremella hypogymniae* Diederich & M.S. Christ.**

NOTES. – According to Diederich (1996) this species is very common on *Hypogymnia physodes*. Despite the frequent occurrence of the host, *Tremella hypogymniae* has so far only been reported from Navarra and Huesca (Etayo 2010). Here we extend the known distribution in the study area to include Lleida.

*Specimen examined.* – **SPAIN. LLEIDA:** WNW of Bellver de Cerdanya, NW of Martinet, NW of Aransa, 0.5 km W of El Fornell, on *Hypogymnia physodes* on *Pinus*, 42°25.5'N, 1°38.0'E, 1800 m, 12.viii.1998, P. v.d. Boom 21483 (hb. van den Boom).

***Tremella phaeophysciae* Diederich & M.S. Christ.**

NOTES. – Diederich (1996) reported this species from Andalucía (Córdoba) and Navarra in Spain. Here we report several additional populations.

*Specimens examined.* – **SPAIN. CÁDIZ:** Grazalema, Parc Natural “S<sup>a</sup> de Grazalema”, just E edge of village, on *Phaeophyscia orbicularis* on *Cupressus* along road, 36°45.7'N, 5°20.8'W, 850 m, 2011, P. & B. v.d. Boom 46005 (hb. van den Boom). **MURCIA:** WSW of Murcia, Parc Natural ‘Sierra de Espuña’, W of Alhama de Murcia, near crossing with road to El Berro, edge of *Pinus* forest and some *Quercus coccifera* trees at open place, on *Phaeophyscia*, on *Q. coccifera*, 37°51.15'N, 1°33.7'W, 1130 m, 2011, P. & B. v.d. Boom 45873 (hb. van den Boom). **SORIA:** Soria city, area of Duero river, way to S. Saturio, alder wood, on *Phaeophyscia orbicularis* on *Aesculus*, 900 m, 21.viii.2001, J. Etayo 18369 (hb. Etayo).

***Tubeufia heterodermiae* Etayo**

NOTES. – After its description from Bértiz in Navarra (Etayo 2002), this species was reported from the Netherlands (van den Boom 2004), Belgium (van den Boom & van den Boom 2006), the Czech Republic (van den Boom & Palice 2006), Austria (Hafellner 2009b), Luxembourg (Diederich et al. 2009), Germany (Brackel 2010) and the British Isles (Hitch 2012). Here we enlarge its known distribution to include the south of Spain.

*Specimen examined.* – **SPAIN. CÁDIZ:** NNW of Grazalema, Parc Natural ‘Sierra de Grazalema’, trail ‘Ruta del Pinsapar’ W of road CA-9104, to Benamahoma, N exposed slope with *Quercus coccifera*, *Abies pinsapo* and calcareous outcrops, on *Physcia*, on *Q. coccifera*, 36°46.9'N, 5°24.2'W, 860 m, 2011, P. & B. v.d. Boom 46007 (hb. van den Boom).

***Unguiculariopsis lettaui* (Grumann) Coppins**

NOTES. – Several Spanish specimens of this species were cited by Diederich and Etayo (2000). Here we provide several additional localities.

*Specimens examined.* – **SPAIN. ASTURIAS:** SW of Oviedo, S of Grado, E of Tameza, 2.5 km on road to Pto Maravio, young *Quercus* forest on E exposed slope, on *Quercus*, on *Evernia prunastri*, 43°14.7'N, 6°7.9'W, 800 m, 3.vii.2001, P. & B. v.d. Boom 26759 (hb. van den Boom). **MÁLAGA:** S of Antequera, Parc Natural El Torcal, Jurassic Karst area, limestones, with shrubs and small trees, on *E. prunastri*, 36°57.5'N, 4°32.5'W, 1200 m, 2011, P. & B. v.d. Boom 45948, 45953 (hb. van den Boom). **NAVARRA:** Unzué, Peña de Unzué, carrascal near the top, on *E. prunastri* on *Quercus rotundifolia*, 42°39.4'N, 1°36.9'W, 900 m, 2012, J. Etayo 27836 (hb. Etayo). **SALAMANCA:** Parc Natural Sierra de

Francia, Miranda del Castañar, *Quercus* forest with, on *E. prunastri* on *Quercus pyrenaica*, 40°28.5'N, 6°0.0'W, 610 m, 2011, P. & B. v.d. Boom 46056 (hb. van den Boom).

***Vouauxiella lichenicola* (Linds.) Petr. & Syd.**

NOTES. – This is a very common lichenicolous fungus that occurs on many different *Lecanora* species (Diederich 2003). Here we add *Lecidea exigua* to the list of known hosts. Hladun and Llimona (2002-2007) provided numerous reports of this species from the Iberian Peninsula.

*Specimens examined.* – **SPAIN. MALLORCA:** between Cala D'or and Porto Colom, Cala Arsenau, on *Lecidea exigua* on *Juniperus phoenicea*, 20 m, 3.iv.1997, P. v.d. Boom 18495 (hb. van den Boom). **NAVARRA:** valle de Lana, way from Ullibarri, old oak forest, on *Lecanora carpinea* gr. on *Quercus pubescens*, ca. 500 m, 4.i.1998, J. Etayo 14209 (hb. Etayo). **SORIA:** Rioseco, sabinar de Rioseco, on *Lecanora chlarotera* on *Juniperus thurifera*, ca. 1000 m, 27.ix.1998, J. Etayo 16053 (hb. Etayo).

***Weddellomyces macrosporus* D. Hawksw., Renob. & Coppins**

NOTES. – This species is a parasite on *Aspicilia calcarea*. It was previously known from the British Isles, France, Germany, Turkey and northern Spain (Cataluña and Basque country) (Navarro-Rosinés & Roux 1995). Here we enlarge its known distribution in the study area to include the center of the Iberian Peninsula.

*Specimen examined.* – **SPAIN. SORIA:** Yanguas, on rockface near the church in the village, on *Aspicilia calcarea*, 1000 m, 16.v.1999, J. Etayo 17005 (hb. Etayo).

***Weddellomyces xanthoparmeliae* Calat. & Nav.-Ros.**

NOTES. – Since the time of its description, this species was known on the Iberian Peninsula only from the type locality in Madrid (Calatayud & Navarro-Rosinés 1998). Here we provide a second report, this one from Soria.

*Specimen examined.* – **SPAIN. SORIA:** Yanguas, on rockface near the church in the village, on *Xanthoparmelia protomatrae* on siliceous rocks, 1000 m, 16.v.1999, J. Etayo 16984 (hb. Etayo).

***Xanthoriicola physciae* (Kalchbr.) D. Hawksw.**

NOTES. – This is one of the most common lichenicolous fungi in Central and Western Europe, as well as on the Iberian Peninsula (Llimona & Hladun 2001). We here add a number of new localities.

*Specimens examined.* – **SPAIN. MALLORCA:** SW of Palma, S of Santa Ponça, Punta Enguisa, *Pinus* wood, on *X. parietina* on *Pistacia* (dead branch), 100 m, 30.iii.1997, P. v.d. Boom 18277 (hb. van den Boom). **LLEIDA:** SW of Bellver de Cerdanya, 0.8 km S of Nas path from manege to Mirador, on *Xanthoria parietina* on *Buxus*, 42°20.8'N, 1°44.5'E, 1300 m, 9.viii.1998, P. v.d. Boom 21335 (hb. van den Boom). **BURGOS:** Santo Domingo de Silos, Peñas de Cervera, sabinar near the river Mataviejas, on *X. parietina* on *Juniperus thurifera*, ca. 900 m, 9.ii.1997, J. Etayo 14251 (hb. Etayo). **LA RIOJA:** Tierra de Cameros, Gallinero de Cameros, grove near stream, on *X. parietina* on a trunk, 1000 m, 11.iv.1996, J. Etayo 14279 (hb. Etayo), J. Etayo 14293 (hb. Etayo). **NAVARRA:** Tafalla, Monte Plano, on *X. parietina* on *Quercus rotundifolia*, 4.v.1993, J. Etayo 1140 (hb. Etayo); Bardenas Reales, laguna de Rada, gypsiferous soil below pinewood, on *X. parietina* on branches of a shrub, 370 m, 14.iii.1988, J. Etayo 14956 (hb. Etayo); Fustiñana, Reserva Natural Caídas de la Negra y Juego de Pelota, on *X. parietina* on twigs of a shrub, ca. 600 m, 26.ii.1995, J. Etayo 15126 (hb. Etayo). **SORIA:** Yanguas, on rockface near the church in the village, on *X. parietina* on *Quercus ilex*, 1000 m, 16.v.1999, J. Etayo 16991 (hb. Etayo); Abejar, sabinar, on *X. parietina* on *J. thurifera*, 1100 m, 27.ix.1998, J. Etayo 16072 (hb. Etayo). **TARRAGONA:** Baix Ebre, Roquetes, camino Ports de Beceite, 2 km crossroad to monte Caro, on *X. parietina* on *Q. rotundifolia*, 13.vii.1995, J. Etayo 1457 (hb. Etayo). **VALENCIA:** SSE of Xàbia, Cap de la Nau, near lighthouse, some *Pinus* trees and mixed shrubs (*Juniperus*, *Olea*, *Pistacia*), on *Xanthoria parietina* on *Pistacia*, 38°44.0'N, 0°13.7'E, 35 m, 15.vi.2009, P. v.d. Boom 43200 (hb. van den Boom).

***Xenonectriella leptaleae* (J. Steiner) Rossman & Lowen**

(= *Pronectria leptaleae* (J. Steiner) Lowen)

NOTES. – This species has an orange perithecial wall and was combined into *Xenonectriella* by Rossman et al. (1999). Like other *Xenonectriella* species, the ascospores are ornamented and turn brown at

maturity. In our material the reactions of the perithecial wall seems to be variable, from K– to K+ intensive orange (K+ pale brown to black, according to Rossman et al. 1999). This variability requires further study to determine whether multiple taxa are involved.

*Specimens examined.* – **SPAIN. CÁDIZ:** WSW of Grazalema, Parc Natural ‘Sierra de Grazalema’, S of road A372, 0.5 km E of crossing with road A2302, *Pinus* forest with *Betula* and *Quercus suber*, calcareous outcrops, trail to the east, on *Physcia*, 36°45.73'N, 5°20.8'W, 850 m, 2011, P. & B. v.d. Boom 45981 (hb. van den Boom); Grazalema, Parc Natural “S<sup>a</sup> de Grazalema”, just E edge of village, on *Phaeophyscia orbicularis* on *Morus nigra* along road, 5°20.8'W, 36°45.73'N, 850 m, 2011, P. & B. v.d. Boom 46001 (hb. van den Boom). **HUELVA:** N of Aracena, S<sup>a</sup> de Aracena y Picos de Aroche, road from Aracena to Castañuelo, edge of old *Castanea* forest, on *Physcia adscendens* on *Quercus ilex*, 37°54.74'N, 6°34.07'W, 710 m, 12.ix.2007, P. & B. v.d. Boom 38549 (hb. van den Boom). **SALAMANCA:** Parc Natural Sierra de Francia, Miranda del Castañar, oak forest with, 6°0.0'W, 40°28.5'N, on *Physconia distorta* on *Q. pyrenaica*, 610 m, 2011, P. & B. v.d. Boom 46053 (hb. van den Boom).

***Xenonectriella septemseptata* (Etayo) Etayo & van den Boom comb. nov.**

Mycobank #807030.

Basionym: *Pronectria septemseptata* Etayo, Nova Hedwigia 67: 507. 1998. **TYPE: SPAIN. NAVARRA:** Sierra de Urbasa, Crezmendi, on *Melanelixia glabratula* on *Fagus sylvatica*, 1100 m, 23.xii.1993, J. Etayo 14340 (MA-Lich.!, holotype).

NOTES. – The genus *Xenonectriella* was separated from *Pronectria* by its K+ purplish ascomatal wall and ascospores that are ornamented, initially hyaline but turning brownish or brown at maturity (Etayo 2010, Rossman et al. 1999). We have observed another feature in *Xenonectriella*, the presence of very wide, septate, hamathecial hyphae with a very thin wall barely visible without DIC microscopy. So far we have not seen those hyphae in any *Pronectria* species. As *Pronectria septemseptata* fits well with the characters of *Xenonectriella* outlined above, we propose the new combination for *P. septemseptata*, a parasite on foliose lichens of the genera *Melanelixia* and *Melanohalea*.

The species is easily recognized by its ascomata that are at first immersed then erumpent, orange, KOH+ purple excepting the papillae, abundant paraphyses 2–6 µm thick, and large brownish ascospores (35–75 × 4.5–7 µm) with (3–5–)7(–10)-septa. For a long time it was known only from the type locality in Spain (Navarra), although recently the species has also been reported from France (Roux 2012), Italy (Brackel 2011), Germany (Brackel et al. 2012) and Luxembourg (Diederich et al. 2012). During recent fieldwork we found a new, very large population of this species in an old *Fagus* woodland in Gipuzkoa Province (Basque Country, northern Spain). In addition to documenting this population we also provide the first Austrian records of this species kindly provided to us by F. Berger.

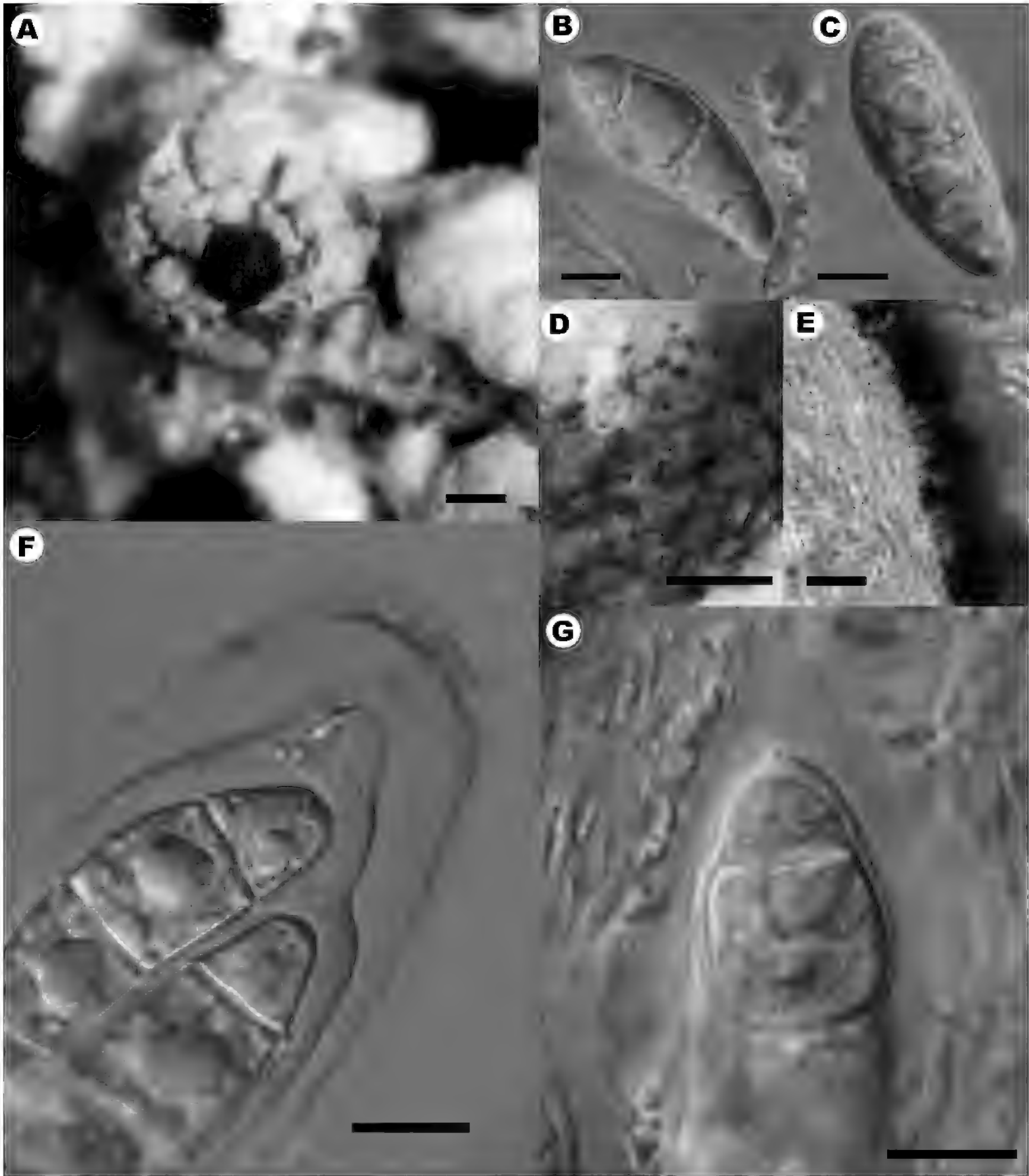
*Specimens examined.* – **AUSTRIA. BEZIRK SCHÄRDING:** Donautal, Engelhartzell, Forstweg Fallau, *Fagus sylvatica*, MTB 7447, 400 m, 2008, F. Berger 22606 (hb. Berger); Sauwald, Vichtenstein, Haugstein, Blockhalde „Mäuern“, *Acer pseudoplatanus*, MTB 7447, 780 m, 2013, F. Berger 27065 (hb. Berger). **SPAIN. GIPUZKOA:** S<sup>a</sup> de Aralar, from Lareo to Enirio by track, *Fagus* forest, on *M. glabratula* on *F. sylvatica*, 42°58.6'N, 2°5.2'W, 775–790 m, 2010, J. Etayo 25947 (hb. Etayo).

***Zwackhiomacromyces* Etayo & van den Boom, gen. nov.**

Mycobank #803963.

**FIGURE 3.**

DIAGNOSIS. – Lichenicolous fungi with ascomata perithecioid, black, pyriform, with ostiole largely papilliform, granulose and opening radially. Ascomatal wall dark, composed of several layers of cells forming a pseudoparenchymatous texture the outermost with extracellular, sometimes granulose pigment. Hamathecium composed of branched and anastomosed pseudoparaphyses, lacking periphyses and periphysoids. Centrum I-. Asci elongate-clavate, fissitunicate, lateral thick-walled, apically thickened and with an ocular chamber. Ascospores ellipsoid, (2–)3-septate, hyaline, without a subapical germ-pore-like spot, smooth-walled.



**Figure 3,** *Zwackhiomacromyces constrictocarpus* (all from the holotype). A, immersed, papillate perithecia. B and C, ascospores. D, granulate pigment in pseudothecial wall. E, transverse section of the perithecial wall. F-G, ascus tips. Scales: A = 0.1 mm; B-F = 10  $\mu$ m.

ETYMOLOGY. – The name *Zwackhiomacromyces* intended to denote the similarity to *Zwackhiomyces*, a genus which shares several characters in common, but which differs in the larger size of their structures and 3-septate instead of 1-septate ascospores.

NOTES. – The genus *Zwackhiomacromyces* must be compared with *Zwackhiomyces*. This latter was described by Grube and Hafellner (1990) and contains 32 species (Lawrey & Diederich 2012, Pérez-Ortega et al. 2011) including one described below. A key to several of these species appears in Calatayud et al. (2007). The characteristic features of the genus are: perithecioid ascomata, branched and anastomosing interascal filaments, fissitunicate asci and 1-septate ascospores. Regarding its hamathecial structures, asci and ascospores, the genus is very homogeneous, although some species deviate somewhat such as *Z. lecanorae* (Stein) Nik. Hoffmann & Hafellner with simple spores or *Z. cervinae* Calat., Triebel & Pérez-Ortega with ascospores that have a perispore and eventually turn brown.

While working through our material from the Iberian Peninsula we discovered a species that differs from all known members of *Zwackhiomyces* in its lageniform ascomata with large and granulose papillae, larger asci, and larger, smooth-walled and normally 3-septate ascospores. Rather than expand the circumscription of that genus we have elected to introduce a new genus, *Zwackhiomacromyces*. We hypothesize that the new genus probably belongs to the Xanthopyreniaceae in the Ascomycota *incertae sedis*.

The ascomatal wall and large ascospores of *Zwackhiomacromyces* are similar to those of species of *Rhagadostoma* in having large cells with a thin wall. But, that genus possesses very different pseudoparaphyses which are made of up large and evanescent cells. Additionally all known species of *Rhagadostoma* have 1-septate ascospores.

Navarro-Rosinés and Roux (1996) described *Clauzadella gordensis* Nav.-Ros. & Roux as a parasymbiotic lichenicolous fungus growing on the thallus of *Verrucaria viridula*. That species is similar to our new taxon in having 3-septate, hyaline ascospores that are  $(15-17-23(-26) \times 6-8 \mu\text{m}$  in size. However, it differs in having a violet pigmentation in the thicker ascomatal wall and, especially in having a completely different hamathecium composed of well developed periphyses and periphysoids, but without pseudoparaphyses.

The type species, and several other members, of the genus *Weddellomyces* (Hawksworth 1986) differ from *Zwackhiomacromyces* by the presence of cephalothecioid plates in the upper part of the perithecia. The remaining species of *Weddellomyces* that lack this feature were added more recently by Alstrup and Hawksworth (1990). According to the generic concept of Navarro-Rosinés et al. (2001), all species of *Weddellomyces* have brown ascospores. The genus *Pseudopyrenidium* Nav.-Ros., Zhurb. & Cl. Roux (Navarro-Rosinés et al. 2010), segregated recently of *Pyrenidium*, also has ascospores that eventually turn brown. Other distinct features which distinguish *Pseudopyrenidium* from *Zwackhiomacromyces* are the perithecia which are not papillate, paraphyses simple or slightly branched at the base, not anastomosing, with pseudoparaphyses and periphyses, asci 4-spored and ascospores with a granulose-verrucose ornamentation.

***Zwackhiomacromyces constrictocarpus* Etayo & van den Boom, sp. nov.**

Mycobank #803964.

**FIGURE 3.**

DIAGNOSIS. – Lichenicolous fungus in thallus of *Megalospora verrucosa*. Ascomata perithecioid, pyriform, papillate, black, 200–300  $\mu\text{m}$  in diam., brown wall 15–20  $\mu\text{m}$  wide. Pseudoparaphyses branched to anastomosing, 1–1.5(–2)  $\mu\text{m}$  thick. Asci elongate clavate, 8-spored, ca.  $150-185 \times 35-40 \mu\text{m}$ . Ascospores hyaline, ellipsoid, (2–)3-septate,  $32-46 \times 13.5-18(-20) \mu\text{m}$ .

**TYPE: SPAIN. ASTURIAS:** SW of Oviedo, Park Natural Somiedo, SE of Pola de Somiedo, 5.5 km ESE of Lago del Valle, S slope with limestone outcrops nearby Lago del Valle, on *Megalospora verrucosa* on mosses of N side of rock, 43°2.5'N, 6°8.6'W, 1550 m, 8.vii.2001, P. & B. van den Boom 27046 (BCN!, holotype; hb. van den Boom!, isotype).

DESCRIPTION. – Ascomata perithecioid “pseudothecia”, arising singly, erumpent, breaking through the cortex of the thallus of *Megalospora*, 200–300  $\mu\text{m}$  diam., black, pyriform, ostiolate, constricted below the papille; the ostiole largely papilliform and opening radially, papillae 120–170  $\mu\text{m}$  diametro, with a



granulose surface. Ascomatal wall dark brown, N–, composed of several layers of prismatic to polyhedral, applanate, pseudoparenchymatous cells, cells of  $10\text{--}15 \times 4\text{--}7 \mu\text{m}$  in section, the outermost layer dark brown,  $15\text{--}20 \mu\text{m}$  thick, with irregular walls, thin in some zones and thicker in the ends, with extracellular pigment, sometimes granulose, especially around the ostiole, the innermost layers subhyaline,  $5\text{--}7 \mu\text{m}$  thick, composed of several rows of very thin, applanate cells. Hamathecium persistent, composed of a dense net of branched and anastomosed pseudoparaphyses, septate,  $1\text{--}1.5\text{--}(2) \mu\text{m}$  wide, thicker in the septa sometimes to  $3\text{--}4 \mu\text{m}$ , lacking paraphyses and paraphysoids, centrum I–. Asci (6–)8-spored, elongate-clavate, fissitunicate, short stalked, thick-walled of  $4\text{--}5 \mu\text{m}$  the sides, I+ orange (dextrinoid), apically thickened with an ocular chamber, ca.  $150\text{--}185 \times 35\text{--}40 \mu\text{m}$ . Ascospores distichously arranged in the asci, ellipsoid to broadly ellipsoid, straight, rarely slightly curved, rounded at the apices, rarely mucronate or subacute, with wider central cells, sometimes lower attenuated, (2–)3-septate, constricted at the septa, sometimes broken in the central septum, hyaline, contents I+ orange, guttulate, without a subapical germ-pore-like spot, smooth-walled, lacking a conspicuous sheath, sometimes with a small torus,  $32\text{--}46 \times 13.5\text{--}18\text{--}(20) \mu\text{m}$ . Conidiomata not observed. Vegetative hyphae not distinct.

HOST. – The new species lives on the thallus of *Megalospora verrucosa* without causing visible damage, so it is considered as a parasymbiont.

DISTRIBUTION. – *Zwackhiomacromyces constrictocarpus* is known only from the type locality in northern Spain and is considered to be a rare species because it has not been collected again in spite of its large ascomata.

NOTES. – *Zwackhiomacromyces constrictocarpus* should be compared with species of *Zwackhiomyces*, but none of the species of *Zwackhiomyces* have triseptate ascospores, pseudothecia with constricted form in section, or such conspicuous papillae. The *Zwackhiomyces* species with the largest ascospores are *Z. cervinae* Calat., Triebel & Pérez-Ortega (Calatayud et al. 2007) and *Z. macrosporus* Alstrup & Olech (Alstrup & Olech 1993) (their ascospores are  $27\text{--}38 \times 8\text{--}10 \mu\text{m}$  and  $37\text{--}43 \times 8.5\text{--}10 \mu\text{m}$  respectively), and both of these show some deviating features from *Zwackhiomyces* (Calatayud et al. 2007, Etayo & Sancho 2008). *Zwackhiomyces cervinae* differs from the rest of the genus in having interascal filaments, relatively wide ascospores with a halo and that become brown when overmature ones are brown. *Zwackhiomyces macrosporus* has been suggested to possibly be a species of *Rhagadostoma* when *R. pannariae* Etayo was treated by Etayo and Sancho (2008).

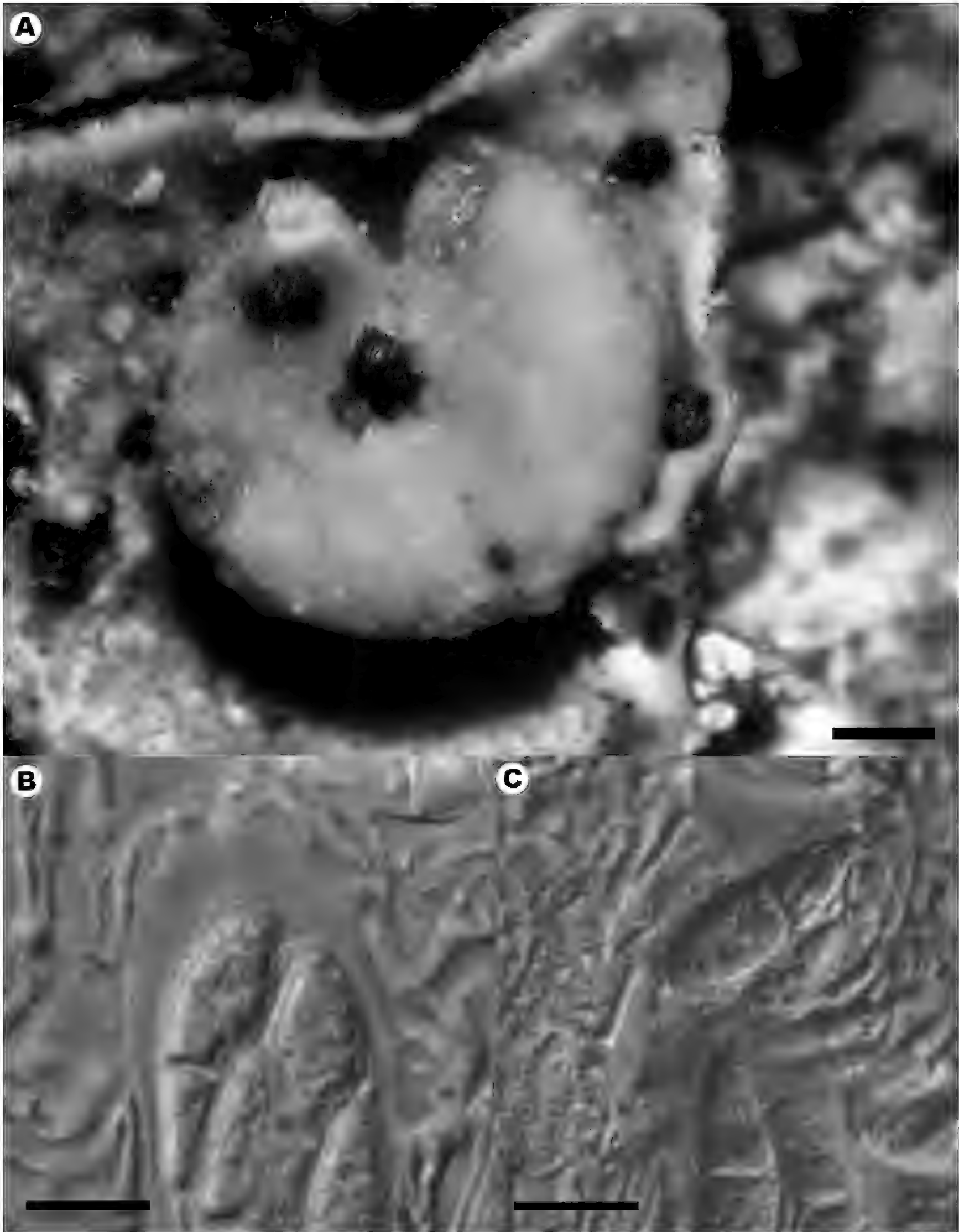
The new species is similar to *Pyrenidium hyalosporum* Alstrup, D. Hawksw. and R. Sant. (Alstrup & Hawksworth 1990) in having large, hyaline, 3-septate ascospores. However, the ascospores of that species have a subapical germ-pore-like structure (in some ascospores of *Z. constrictocarpus* similar structures were observed but seem to be small apical guttules), are 3–4-septate, and narrower ( $(31\text{--})34\text{--}39\text{--}(45) \times (7.5\text{--})10\text{--}12.5\text{--}(14) \mu\text{m}$ ). Additionally, that species occurs on a different host (*Placopsis*). In the description of *P. hyalosporum* Alstrup and Hawksworth (1990) discussed the differences between their new taxon and members of the genus *Cercidospora*. These authors were also not completely convinced that their taxon should be included in *Pyrenidium*, particularly because of its hyaline ascospores with a germ-pore-like structure (whereas most other species of that genus have brown ascospores without germ-pore-like structures when young). We agree that their hesitation was warranted and are convinced that *P. hyalosporum* does not belong to *Pyrenidium*, an opinion also maintained by Navarro-Rosinés (pers. com.).

***Zwackhiomyces melanohaleae* Etayo & van den Boom, sp. nov.**

Mycobank #803962

FIGURE 4.

DIAGNOSIS. – Lichenicolous fungus growing in thalli of the genus *Melanohalea*. Ascomata black,  $100\text{--}180 \mu\text{m}$  diam., paraphyses branched,  $1\text{--}1.5 \mu\text{m}$  wide, ascus  $65\text{--}75 \times 20 \mu\text{m}$ , 8-spored, ascospores 1-septate, ovoid, hyaline,  $(18\text{--})20\text{--}25\text{--}(27) \times 7.5\text{--}10 \mu\text{m}$ , cells with 1–3 oil guttules.



**Figure 4,** *Zwackhiomyces melanohaleae* (all from the holotype). A, habit. B, ascus tip and interascal filaments. C, ascospores and interascal filaments. Scales: A = 200  $\mu\text{m}$ ; B and C = 10  $\mu\text{m}$ .

**TYPE: SPAIN. CÁDIZ:** NNW of Grazalema, Park Natural ‘Sierra de Grazalema’, trail ‘Ruta del Pinsapar’ W of road CA-9104, to Benamahoma, N-exposed slope with *Quercus coccifera*, *Abies pinsapo* and calcareous outcrops, on *Melanohalea exasperata* on *Q. coccifera*, 36°46.9'N, 5°24.2'W, 860 m, 11.vi.2011, P. & B. van den Boom 46011 (BCN!, holotype; hb. van den Boom!, isotype).

**DESCRIPTION.** – Ascomata perithecioid “pseudothecia”, black, widely obpyriform, slightly conical at the top, ca. 100–180 µm diam., scattered, first immersed, especially in papillae of the host, becoming sessile with only the base sunken in the host tissues, not causing radial superficial fissures around the ostiole, ostiole ca. 40 µm diam. (in water). Ascomatal wall pseudoparenchymatous, of *textura angularis*, dark brown, in section ca. 20 µm wide in the lower and central part and wider near the ostiolum, 30–40 µm, with the innermost layers of cells paler and with a thinner wall than the outermost. Cells of the wall polyhedral to prismatic, 5–8 µm wide, brown wall pigments deposited between the cells, granulose, turning black with K; the wall is irregular, in prismatic ones are thin in the middle and thicker in the ends. Hymenial gel I–, K/I–. Hamathecium persistent, composed of abundant, branched and anastomosing, 1–1.5 µm wide filaments. Asci cylindrical to slightly clavate, 8-spored, wall thickened at the apex, with an ocular chamber, I–, K/I–, fissitunicate, 65–75 × 20 µm. Ascospores 1-septate, constricted in the septa, hyaline, right to slightly curved, (18–)20–25(–27) × 7.5–10 µm, perispore observed in young spores specially, both cells usually of different size, the lower is smaller, in some almost caudate, with one large or two or three smaller lipid guttules (not disappearing in KOH).

**HOST.** – *Zwackhiomyces melanohaleae* lives parasitically on *Melanohalea exasperata*. It does not deform the thallus, but causes a discoloration of the host that turns withish or yellowish in the infected areas, even in the apothecial disc.

**DISTRIBUTION.** – The new species is known only from the type locality in southern Spain.

**NOTES.** – *Zwackhiomyces* is morphologically very homogeneous. To date two species of *Zwackhiomyces* have been described from parmelioid lichens in southern hemisphere: *Z. kantvilasii* S. Kondr. on *Parmotrema perlatum* (Kondratyuk 1996) and *Z. sulcatus* Pérez-Ortega & Etayo (Pérez-Ortega et al. 2011) on *Austroparmelina*. Both of these species differ from the one described here in having globose ascomata with radial superficial fissures around the ostiole, the latter being more accentuated in *Z. sulcatus*. Furthermore, the ascospores are larger in *Z. melanohaleae* than in the other two species ((14–)16–18.6–21(–23) × (4–)5–5.5(–7) µm in *Z. sulcatus* and (11–)12–14.2–15(–16) × 3–5(–5.5) µm in *Z. kantvilasii*). Other species we can compare *Z. melanohaleae* with are *Z. echinulatis* Brackel and *Z. solenopsorae* van den Boom. The first has ascospores 24–27 × 9.3–11 µm in size, which are somewhat wider than those of the new species. Additionally, the ascomata are larger (100–250 µm) and globose, and it is known from a different host *Physconia distorta*. *Zwackhiomyces solenopsorae* has ascospores of a similar size to those of the new species (15–25 × 7–9 µm), but they have a smooth surface, the ascomata are ± immersed and smaller, 70–150 µm diam., and the host is *Solenopsora holophaea*.

#### ACKNOWLEDGEMENTS

We would like to thank Franz Berger for kindly permitting us to publish his records of *X. septemseptata*, Mireia Giralt for checking a *Rinodina* specimen, David L. Hawksworth for helping us to resolve some nomenclatural questions and to Paul Diederich, James C. Lendemer and an anonymous reviewer for useful comments on the manuscript. Harrie Sipman kindly read the manuscript and made several corrections. Bern van den Boom is thanked for all her help with fieldwork over the years.

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## A new species of *Lecidea* (Lecideaceae, Lichenized Ascomycetes) from the mountains of California

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**ABSTRACT.** – *Lecidea oreophila*, a species similar to *L. tessellata*, is described from the mountains of California (Sierra Nevada, San Bernardino, San Jacinto) from sites above 1958 meters in elevation. The new species produces 2'-*O*-methylmicrophyllinic acid with or without confluent acid.

**KEYWORDS.** – Alpine lichens, montane lichens, taxonomy.

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### INTRODUCTION

The *Lecidea* species of the Sonoran Desert Region in western North America were recently monographed by Hertel and Printzen (2004). That monograph was an important step forward in the study of the North American lichen flora because the genus *Lecidea*, like other crustose genera such as *Acarospora* and *Aspicilia*, was still poorly understood at the beginning of the 21<sup>st</sup> century. Nonetheless, the problems in *Lecidea* s. str. in western North America are far from resolved. The delineation of species and infraspecific taxa in the *L. fuscoatra* and *L. atrobrunnea* groups needs re-examination (for instance see Hutten et al. 2013). A number of endolithic species including *L. cruciaria* Tuck. and *L. kingmanii* (Hasse) Hertel & S. Ekman are in need of revision. Several new taxa have been discovered (Knudsen et al. 2013). In this paper we describe one of these new taxa from the mountains of California.

### MATERIALS AND METHODS

Specimens were examined using standard microscopical techniques with an Olympus SZX 7 stereomicroscope or an Olympus BX 51 fitted with Nomarski differential interference contrast. Specimens were compared with material in the Herbarium Mycologium of J. Kocourková and K. Knudsen from the mountains of the Czech Republic and specimens in the herbaria of GZU, NY and UCR. Secondary metabolites were studied using standardized thin-layer chromatography in Solvent C (Culberson & Ammann 1979, Culberson & Johnson 1982, Orange et al. 2001, 2010). Hand cut sections were studied in water and 10% KOH (K). Amyloid reactions were tested in Lugol's iodine [I] with and without pretreatment with K. Nitric acid 70% was used for chromatic reactions of inspersion. Ascospores and conidia were measured in water with an accuracy of 0.5 µm and given in the form "(minimum–) mean minus standard deviation–average–mean plus standard deviation (–maximum)" rounded to nearest 0.5 microns and followed by the number of measurements (*n*); the length/breadth ratio is indicated as l/b and given in the same way.

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## THE NEW SPECIES

### *Lecidea oreophila* K. Knudsen & Kocourk., sp. nov.

Mycobank #809259.

FIGURE 1.

Similar to *Lecidea tessellata*, but has a dark hypothecium and produces 2'-*O*-methylmicrophyllinic acid as the primary substance, with or without accessory confluent acid.

TYPE: U.S.A. CALIFORNIA. RIVERSIDE CO.: San Bernardino National Forest, San Jacinto Mountains, Black Mountain, Black Mountain Fire Outlook area, 33°49'28"N, 116°45'31.4"W, 2349 m, 10.viii.2012, on large granite boulders, K. Knudsen 15013 (UCR!, holotype).

DESCRIPTION. – Thallus to 10.0 cm or more in diameter, but often smaller, irregularly areolate with deep fissures between areoles, not flat or thin in appearance, areoles to 2.0 mm wide, to 0.5 mm thick, variable in shape, vegetatively dividing, broadly attached. Upper surface rugulose, light to dark gray, sometimes slightly bluish. Apothecia to 1.0 mm wide, margin thin and persistent, disc flat to convex, epruinose, arising from the areoles, usually higher than thallus surface, vegetatively dividing, first appearing on top of the areoles, eventually expanding to give the appearance of occurring between areoles. Cortex 10–30 µm thick, of round to angular cells, mostly 4–5 µm wide, becoming gelatinized below a thin epinecral layer. Algal layer 80–120 µm, uninterrupted, algal cells 8–15 µm wide. Medulla I+ violet, 0.1–0.4 mm thick, often obscured by crystals, prosoplectenchymatous, hyphae 4–6 µm in width, thin-walled, sometimes rugulose, branching, continuous with attaching hyphae.

Exciple 60–90 µm wide, of radiating hyphae, hyphae 1.5–2.0 µm in width, apices expanded to 5 µm, thin outer layer green-black, internally hyaline. Epihymenium green-black, ca. 10 µm tall, N+ reddish-purple. Hymenium 60–80 µm tall. Asci clavate, 8-spored, mostly 40–50 × 20–40 µm. Ascospores hyaline, thin-walled, (12–)12–13–14 × (4–)4.5–5.5–6 µm (n=20), l/b = 2.0–2.5–3.0(–3.5). Paraphyses 1.5–2.0 µm wide, rarely branching, apices expanded up to 5 µm. Subhymenium 30–40 µm tall, pigmented light or dark brown in thin section, darker in thick section, N+ reddish-purple, not easily distinguished from hypothecium. Hypothecium 80–100 µm, pigmented light to dark brown, N+ reddish-purple. Pycnidia, ostiolate, not graphidoid, appearing as dark dots. Conidia hyaline, (9.0–)10–13–15.5(–20) × 1–2 µm (n=40).

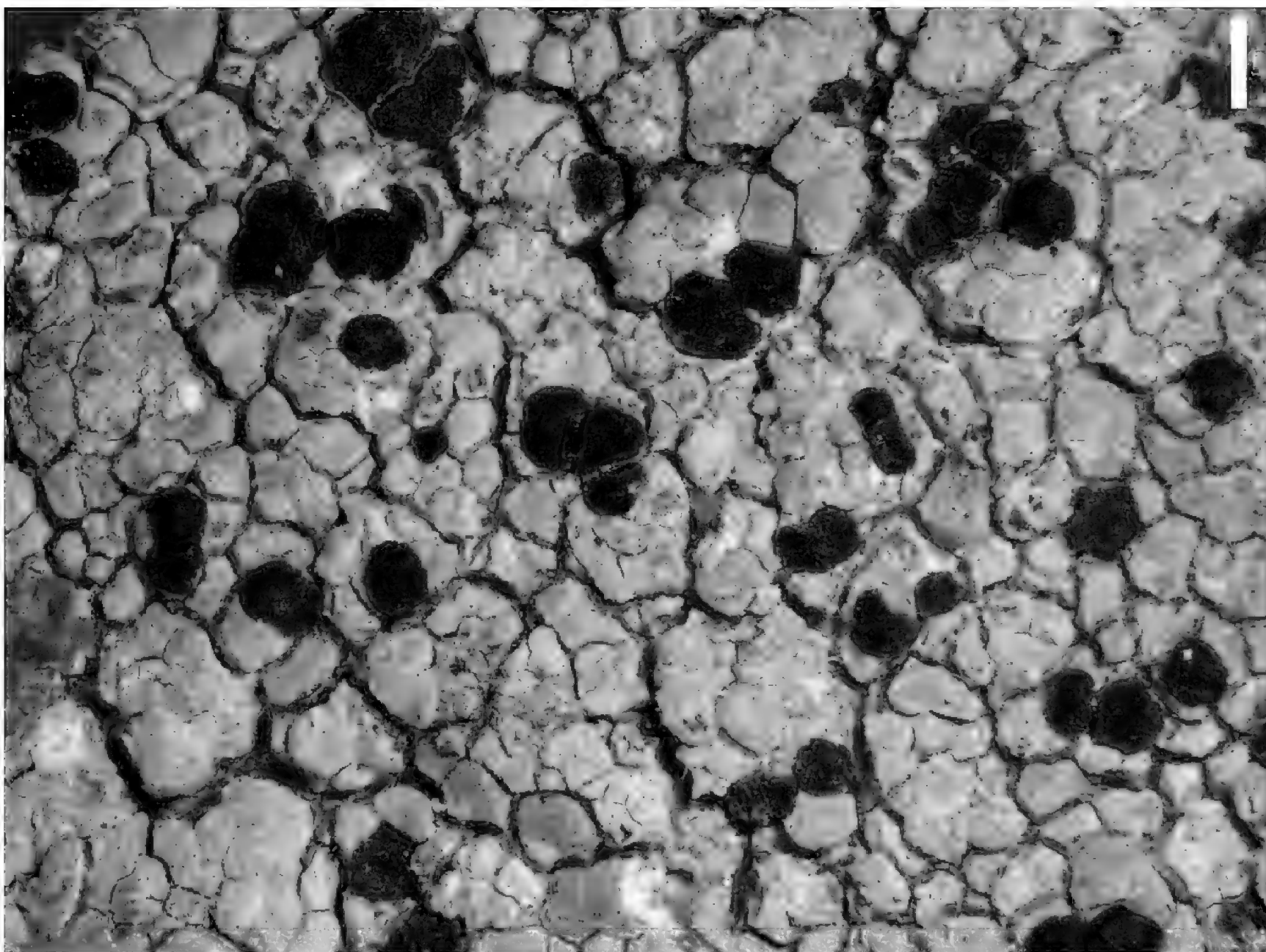
CHEMISTRY. – 2'-*O*-methylmicrophyllinic acid (major), with or without confluent acid (major), with or without a trace of 2'-*O*-methylperlatolic acid.

ETYMOLOGY. – The epithet “oreophila” means “mountain lover” and refers to the occurrence of the species in the mountains of California above 1958 meters.

ECOLOGY AND DISTRIBUTION. – *Lecidea oreophila* is locally frequent. It occurs above 1958 meters on granite in saxicolous montane communities usually associated with members of the *Lecidea atrobrunnea* complex. It is known from scattered localities in the mountain of central and southern California (Sierra Nevada Mountains; San Bernardino Mountains; San Jacinto Mountains).

DISCUSSION. – *Lecidea oreophila* belongs to *Lecidea* sensu stricto based on ascus stain (Hertel & Printzen 2004) and is similar to *L. tessellata* Flörke. The irregularly areolate thallus with apothecia usually higher than the areoles separates *L. oreophila* from the regularly areolate thallus of *L. tessellata* which has been described as having “half-sunken” apothecia (Hertel & Printzen 2004; for image of a typical thallus see Brodo et al. 2001). *Lecidea tessellata* has graphidoid pycnidia, a usually hyaline hypothecium, and the consistent production of confluent acid (Hertel & Printzen 2004). *Lecidea oreophila* differs in having non-graphidoid pycnidia, a dark subhymenium and hypothecium in thin section, and the consistent production of 2'-*O*-methylmicrophyllinic acid with or without accessory confluent acid. In California, *L. tessellata* is the only species of the genus in montane communities with which *L. oreophila* could be confused. In southern California, based on 25 collections from UCR (UCR Herbarium 2014), *L. tessellata* is common but was not collected above 2056 m and often occurs at lower elevations down to 635 m in the Santa Ana Mountains. *Lecidea tessellata* also occurs in the Little San Bernardino Mountains of Joshua Tree





**Figure 1**, holotype of *Lecidea oreophila* from the San Jacinto Mountains, K. Knudsen 15013 (UCR), scale = 1.0 mm.

National Park in the southwestern Mojave Desert (Knudsen et al. 2013; image in Sharnoff 2014). During our fieldwork throughout the region where *L. oreophila* is known to occur, *L. tessellata* was not found in any communities with *L. oreophila*.

*Lecidea oreophila* could also be confused with *L. lapicida* (Ach.) Ach. which is not known from western North America (Hertel 2006, Hertel & Printzen 2004). *Lecidea lapicida* has ascospores of the same general length as *L. oreophila* but the mature ascospores are generally more broadly ellipsoid (6–8  $\mu\text{m}$  wide vs. 4–6  $\mu\text{m}$  in *L. oreophila*; fide Aptroot et al. 2009). In his excellent monograph on *Lecidea* s. str., though Schwab gave different and smaller spore sizes for *L. lapicida*, he nonetheless considered the ascospores of *L. lapicidia* to be broadly ellipsoid (Schwab 1986). The ascospores of *L. oreophila* are usually ellipsoid, though immature spores in the ascus can be globose in early ontogeny. *Lecidea lapicida* differs chemically from *L. oreophila* in lacking 2'-*O*-methylmicrophyllinic acid and confluent acid, and in producing norstictic acid (in *L. lapicida* var. *pantherina* (Hofm.) Ach. [= *L. pantherina* (Hoffm.) Ach.] ) or the stictic acid complex (in *L. lapicidia* var. *lapicida*) (Aptroot et al. 2009).

*Lecidea confluens* is rare in North America (Hertel 2006) with only one report from California (Knudsen 2012). These sites could be Pleistocene relics. The ascospores of *L. confluens* are 9–13  $\times$  4.4–5.6  $\mu\text{m}$  in size (Schwab 1986) and overlap the size range of ascospores in *L. oreophila*, with *L. oreophila* having generally longer ascospores (12–14  $\mu\text{m}$ ). *Lecidea confluens* has a flatter, smoother, regularly areolate thallus (see illustration in Wirth et al. 2013) rather than the irregularly areolate and rugulose thallus of *L. oreophila* (figure 1 herein). *Lecidea confluens* consistently produces confluent acid and 2'-*O*-methylperlatolic acid and sometimes stictic acid (Aptroot et al. 2009). *Lecidea oreophila* differs in producing 2'-*O*-methylmicrophyllinic acid consistently, sometimes with accessory confluent acid and 2'-*O*-methylperlatolic acid. It is quite possible that *L. oreophila* is related to *L. confluens* as well as *L. lapicidia* and thus should be included in future molecular phylogenetic studies of *Lecidea* s. str.



Based on its few recorded occurrences, we currently consider *Lecidea oreophila* to be rare. In the San Jacinto Mountains, the species could become extirpated by wildfires. The 2013 Mountain Fire in the San Jacinto Mountains, which devastated over 30-square-miles of suitable habitat where *L. oreophila* could have occurred, prevented more fieldwork aimed at locating additional populations. Fortunately the fire did not extirpate any of the populations of *L. oreophila* reported in this paper.

*Additional specimens examined.* – **U.S.A. CALIFORNIA.** MONO CO.: Inyo National Forest, Tioga Pass, 37°55'40.7"N 119°15'21.3"W, 2930 m, 13.vii.2012, on granite outcrops, K. Knudsen et al. 14732 (NY), K. Knudsen et al. 14740.1 (UCR), Knudsen et al. 14740.2 (FH). RIVERSIDE CO.: Mount San Jacinto State Park, San Jacinto Mountains, San Jacinto State Wilderness Area, near trail to Round Valley, 33°48'27"N 116°48'39.6"W, 2676 m, 17.xi.2006, on granite boulders, K. Knudsen 7892 & L. Kuzina (UCR); same locality, 33°48'39.6"N 116°39'02"W, 2699 m, 3.vi.2013, on granite boulders, K. Knudsen 15815 (UCR). SAN BERNARDINO CO.: San Bernardino National Forest, San Bernardino Mountains, 2N02, crossing at Arrastre Creek, pinyon-juniper woodland, 34°15'19.6"N 116°44'39.2"W, 1959 m, 20.iii.2014, on granite outcrop, Knudsen et al. 16510 (NY, hb. Kocourková and Knudsen)

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## *Micarea byssacea* new to North America and *Micarea hedlundii* new to Maine, Michigan and Quebec

ANNINA LAUNIS<sup>1</sup> & LEENA MYLLYS<sup>2</sup>

**ABSTRACT.** – *Micarea byssacea* is reported new to North America from the coastal region of Maine. *Micarea hedlundii* is reported new to the states of Maine and Michigan (U.S.A.) and the province of Quebec (Canada). *Micarea hedlundii* was previously reported for North America only from New Brunswick, Canada and California, U.S.A. Both species have likely been overlooked in North America owing to their inconspicuous thalli. Further studies are needed to fully understand the ecology and distribution of *M. hedlundii*, *M. byssacea* and allied species in North America.

**KEYWORDS.** – New records, biogeography, ecology, taxonomy, crustose lichens.

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### INTRODUCTION

*Micarea* Fr. is a crustose lichen genus (Lecanoromycetes, Ascomycota) containing almost 100 species worldwide (Coppins 2009, Czarota 2007). However, phylogenetic analyses based on molecular data clearly show that the genus is paraphyletic (Andersen & Ekman 2005, Serusiaux et al. 2010), even after the introduction of a new genus *Brianaria* Ekman & Svensson for the *M. sylvicola* group (Ekman & Svensson 2014). The *M. prasina* group, which includes the type species of the genus, *M. prasina* Fr., currently consists of 17 species (Czarota & Guzew-Krzemińska 2010), which all have a “micareoid” photobiont (a coccoid green alga with cells 4–7 µm in diameter), immarginate apothecia, branched paraphyses and an ascus of the *Micarea*-type (Hafellner 1984). All the species in this group occur on bark, especially of old trees or on soft lignum. The majority of the species produce the *Sedifolia*-grey pigment (K+ violet, C+ violet), which is typically present in the apothecia and pycnidia (Coppins 1983, Czarota & Guzew-Krzemińska 2010).

The taxonomy of *Micarea* is incompletely known and many species are still undercollected, probably owing to their small size and inconspicuous thalli. *Micarea prasina* has been divided into several species during the last two decades, including the *M. micrococca* complex that is composed of *M. byssacea* (Th. Fr.) Czarota, Guzew-Krzemińska & Coppins, *M. micrococca* (Körb.) Gams ex D. Hawksw. s. str. and a yet unnamed taxon (Czarota & Guzew-Krzemińska 2010). According to the 19<sup>th</sup> edition of the North American lichen checklist (Esslinger 2014), 40 *Micarea* species are known from North America, of which eight belong to the *M. prasina* group. Here we present the first records of *M. byssacea*, for North America and of *M. hedlundii* Coppins for the states of Maine and Michigan (U.S.A.) and the province of Quebec (Canada). The recent molecular study by Czarota and Guzew-Krzemińska (2010) confirms that both species belong to the *M. prasina* group.

### MATERIALS AND METHODS

*Micarea* specimens were collected by the first author during the Crustose Lichens and Sterile Crustose Lichens workshops at the Eagle Hill Institute, Maine, in June 2012. Specimens were identified

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with a dissecting or compound microscope. Ascospore dimensions and other anatomical measurements were made in water and are presented based on the cited collections and the measurements of Czarnota and Guzow-Krzemińska (2010). Chemical spot tests were performed under a compound microscope using sodium hypochlorite (C) and 10% potassium hydroxide (K) (Orange et al. 2001). Pigments were defined following Coppins (1983), Meyer and Printzen (2000) and Czarnota (2007). Specimens were further studied using thin-layer chromatography following Culberson and Kristinsson (1970) and Orange et al. (2001). Specimens are deposited in the Finnish Museum of Natural History (H) and the New York Botanical Garden (NY).

## THE SPECIES

### *Micarea byssacea* (Th. Fr.) Czarnota, Guzow- Krzemińska & Coppins

FIGURE 1B.

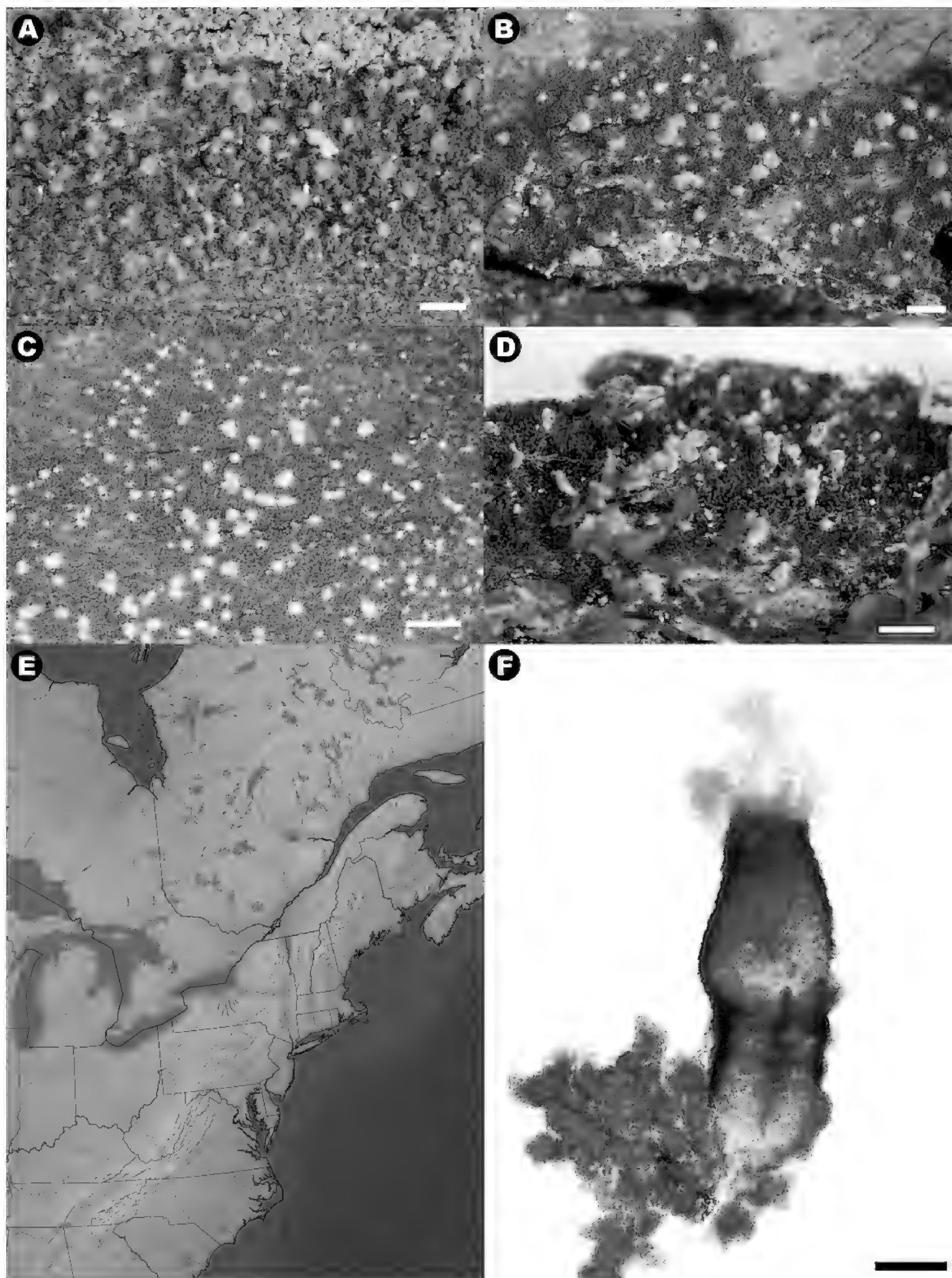
CHARACTERIZATION OF THE SPECIMENS EXAMINED. – Thallus effuse, green to olive-green and minutely granular, composed of small goniocysts. Photobiont micareoid (cells  $\pm$  globose, 4–7  $\mu\text{m}$ ). Apothecia variable in size and color even in the same collection, usually numerous, immarginate and mostly adnate, sometimes convex to hemispherical, 0.2–0.6 mm in diameter, whitish, cream, whitish-grey, olive-grey, or grey to blackish grey, often with paler outer part. Hymenium hyaline, but in darker apothecia the epihymenium is greyish, K $\pm$  violet, C $\pm$  reddish violet due to the presence of *Sedifolia*-grey which is confined to the gel matrix. Hypothecium hyaline or slightly yellowish. Ascus clavate or cylindrical-clavate. Ascospores oblong, oblong-ovoid, ellipsoid, 0(–1) septate, (6–)8–12(–13)  $\times$  2.7–3.5(–4.2)  $\mu\text{m}$ . Pycnidia, not always present, usually immersed to sessile and white to greyish-white (K $\pm$  violet, C $\pm$  reddish violet). In North American material, however, pycnidia are sometimes emergent and dark grey. Mesoconidia (3.8–)4.5–5.5  $\times$  1.2–1.5  $\mu\text{m}$  and microconidia 5–7.5(–8)  $\times$  0.8–1  $\mu\text{m}$ .

CHEMISTRY. – Methoxymicareic acid detected by TLC and the *Sedifolia*-grey pigment detected by chemical spot tests (K and C).

DISTRIBUTION AND ECOLOGY. – *Micarea byssacea* was previously known only from Central and Northern Europe. It is likely widespread but overlooked in North America, often reported as *M. prasina* or *M. micrococca* (*sensu* Coppins) (see below for notes). In eastern Maine, *M. byssacea* was collected from two localities in Washington County: from Great Wass Island Reserve in the Town of Beals and from Eagle Hill in the Town of Steuben. Collections are both from humid natural and semi-natural coastal forests.

In Europe, *Micarea byssacea* is a forest epiphyte occurring on the bark of several tree species such as *Pinus* spp., *Picea* spp. and *Betula* spp. It usually occurs on trees with a low bark pH, although one collection from North America is from *Acer*, which sometimes has less acid bark. On rather rare occasions, the species has been found on more or less hard lignum of decaying stumps of coniferous trees. Almost all known collections of *M. byssacea* are from natural or semi-natural forests. The species obviously thrives in shaded habitats with humid microclimates. However, the distribution and ecological preferences of *M. byssacea* are still incompletely known both in North America and Europe.

NOTES. – Coppins (1983) considered *Micarea prasina* to be a variable species needing taxonomic revision and it has subsequently been divided into several species based on differences in morphology, chemistry and/or DNA characters (e.g. Coppins & Tønsberg 2001, van den Boom & Coppins 2001). *Micarea micrococca* was separated from *M. prasina*, which contains micareic acid, mainly by the presence of methoxymicareic acid (Coppins 2002). However, based on a molecular analysis of the *M. prasina* group, Czarnota and Guzow- Krzemińska (2010) found that *M. micrococca sensu* Coppins is not monophyletic and includes, in fact, three separate lineages: *M. micrococca* s. str. (hereafter referred to as *M. micrococca*), *M. byssacea*, and a yet unnamed taxon. In spite of their similarity in secondary chemistry with all producing methoxymicareic acid, the species have some differences in morphology and ecology. Below we discuss the differences between *M. prasina* (fig. 1A), *M. byssacea* (fig. 1B) and *M. micrococca* (fig. 1C), based on both European and North American material. Because of the taxonomic uncertainties, and the lack of collections from North America, the unnamed taxon is not discussed thoroughly here. Czarnota and Guzow- Krzemińska (2010) considered the unnamed taxon to be cryptic and an intermediate between *M.*



**Figure 1**, morphology of *Micarea* species discussed in this paper (A–D and F) and geographic distribution of *M. hedlundii* in North America (E). A, apothecia and thallus of *M. prasina* (Launis 229106, H). B, apothecia and thallus of *M. byssacea* (Launis 66128, H). C, apothecia and thallus of *M. micrococca* (Launis 1010131, H). D, olive-green thallus composed of goniocysts and stalked lilac pycnidia coated with white tomentum in *M. hedlundii* (Launis 67119, H). E, known geographic distribution of *M. hedlundii* in North America. F, stalked pycnidium releasing mesoconidia in *M. hedlundii* (Launis 66125, H) Scales = 1.0 mm in A–D, 100 µm in E.



*micrococca* and *M. byssacea*. However, our unpublished results and personal comments from P. Czarnota show that some morphological characters are found. These characters include small (0.1–0.3 mm) and adnate to hemispherical apothecia with the *Sedifolia*-grey pigment, or without the pigment but with smaller ascospores than in *M. micrococca*. If specimens like this were to be collected from North America they should be sequenced to determine whether they belong to the unnamed taxon.

Morphologically, *Micarea byssacea* resembles *M. micrococca* and *M. prasina*, but *M. prasina* differs from the first two species by the production of micareic acid and by mainly growing on soft lignum. Although all three species have immarginate apothecia, a thallus composed of goniocysts, and almost no differences in spore sizes, *M. prasina* can quite easily be identified with TLC and also by its preference for decaying lignum instead of bark.

Similarly to *Micarea micrococca*, *M. byssacea* produces methoxymicareic acid and occurs mainly on acid bark. However, *M. byssacea* differs in the presence of the *Sedifolia*-grey pigment (K+ violet, C+ violet), as well as in its larger, adnate and usually darker colored apothecia (Czarnota & Guzow-Krzemińska 2010). In *M. micrococca* the apothecia are colorless throughout in section and always pale externally, without any darker pigmentation. In *M. byssacea* and *M. prasina* the pigmentation of the apothecia is variable, probably in response to the amount of light. Therefore, in shaded habitats the apothecia can be very pale or whitish with no *Sedifolia*-grey pigment, and these forms are not always easy to separate from those of *M. micrococca*. The diagnostic features for the separation of *M. byssacea*, *M. micrococca* and *M. prasina* are presented in more detail in Table 1.

*Micarea byssacea* and *M. micrococca* also differ ecologically, although they can be found growing together. *Micarea byssacea* usually occurs in natural or semi-natural forests whereas, in Central Europe, *M. micrococca* is known for its ecological plasticity; it is found also in managed forests of various ages, and on branches and stems of dwarf shrubs in humid woods (Czarnota & Guzow-Krzemińska 2010). This, however, appears not to be the case in Northern Europe where *M. micrococca* tends to be rarer and is confined to open natural forests. In North America the ecological preferences of the species are still poorly known.

For the reasons discussed above, *Micarea byssacea* appears to be an overlooked species in North America. Further studies, including thorough examination of herbarium material of both *M. micrococca* and *M. prasina*, are needed to fully understand the ecology and distribution of the species complex in North America.

*Micarea byssacea* specimens examined. – **U.S.A. MAINE.** WASHINGTON CO.: Town of Beals, Great Wass Island Reserve, open *Pinus banksiana* forest with heathy understory of *Kalmia*, *Ledum*, *Rhododendron canadense* etc., 6.vi.2012, on bark of old *Pinus*, *A. Launis* 66128 (H); Town of Steuben, Dyer Neck, Eagle Hill, Eagle Hill Institute, humid mixed forest dominated by *Picea rubens*, *Abies*, *Betula* and *Acer rubrum*, 11.vi.2012, on bark of shaded *Acer*, near ground, *A. Launis* 116123 (H).

*European Micarea byssacea* specimens examined for comparison. – **FINLAND.** UUSIMAA: Sipoo, Rörstrand Oldgrowth Forest Nature Reserve, E side of swamp Moraskärr, 28.ix.2010, on bark of shaded old *Alnus glutinosa*, *A. Launis* 289101 (H), on bark of shaded old *A. glutinosa*, *A. Launis* 289102 (H); Sipoo, Rörstrand Oldgrowth Forest Nature Reserve, S side of swamp Moraskärr, 28.ix.2010, on bark of fallen *A. glutinosa*, *A. Launis* 289104 (NY). ETELÄ-HÄME: Hämeenlinna, Evo, Kotinen Nature Reserve, near lake Valkea-Kotinen, 20.viii.2012, on bark of decaying *Picea abies*, *A. Launis* 208121 (H). **SWEDEN.** ÖSTERGÖTLAND: Vadstena region, Omberg, near top of Hjässan, 17.viii.2013, on bark of *Quercus robur*, *Czarnota* s.n. (H).

*Micarea prasina* specimens examined. – **U.S.A. MAINE.** WASHINGTON CO.: Town of Steuben, Dyer Neck, Eagle Hill, Eagle Hill Institute, red trail, costal mixed forest dominated by *Picea rubens*, *Abies*, *Betula* and *Acer rubrum*, 7.vi.2012, on xylem of standing decaying conifer, near ground, *A. Launis* 76122 (H); Town of Beals, Great Wass Island Reserve, humid mixed forest dominated by *Abies*, *Picea rubens*, *Betula cordifolia*, *Sorbus americana*, *Nemopanthus* and *Pinus banksiana*, 6.vi.2012, on xylem of decaying *Abies* sp., near ground, *A. Launis* 66125 (H); Town of Beals, Great Wass Island Reserve, open *Pinus banksiana* forest with heathy understory of *Kalmia*, *Ledum*, *Rhododendron canadense* etc., 6.vi.2012, on decaying xylem of horizontal conifer, *A. Launis* 66127 (H); Town of Cutler, Cutler Public Reserve Land, coast trail 0–1.5 miles between ME 191 and coast, humid mixed conifer (*Abies*, *Picea*, *Thuja*) and hardwood (*Acer*, *Sorbus*, *Betula*) forest, 13.vi.2012, on decaying xylem of standing *Abies*, near ground, *A. Launis* 136121 (H), near seashore, on xylem of dead standing *Abies balsamica*, near ground, *A. Launis* 136123 (H), *A. Launis* 136124 (H), *A. Launis* 136129 (H), *A. Launis* 1361210 (H).



Character / Species	<i>Micarea byssacea</i>	<i>Micarea micrococca</i> (sensu Czarnota & Guzow- Krzemińska)	<i>Micarea prasina</i>
Thallus	minutely granular; goniocyts often finely divided	minutely granular; goniocyts often mealy	minutely granular; goniocyts variable
Thallus color	Green to olive green	Bright green to olive green	whitish-green, bright green to olive-green
Apothecia color	Whitish, cream, whitish- grey, olive-grey, grey to blackish grey	Whitish-cream, cream	Whitish, brownish, greyish, grey-brown, piebald to almost blackish-brown or blackish-grey
Apothecia size (mm)	(0.1–)0.2–0.6	0.1–0.3	0.2–0.4(–0.8)
Ascospores (µm)	0(–1) -septate; (6–)8– 12(–13) x 2.7–3.5(–4.2)	(0–)1 -septate; 10–12(– 16) x 3–4.5	0–1 -septate; (6–)8– 12(–14) x (2.5–)3–4(– 5.5)
Pycnidia	Immersed between goniocyts or sessile; white to greyish-white or rarely dark olive-grey, often with widely gaping ostioles	Immersed between goniocyts or sessile; usually abundant, white to whitish-cream, often with widely gaping ostioles	Immersed between goniocyts or rarely sessile; whitish to olive-grey, often with widely gaping ostioles
Mesoconidia size (µm)	(3.8–)4.5–5.5 x 1.2–1.5	(3.8–)4.5–5.5 x 1.2–1.5	4–5.5(–6) x 1–1.2(– 1.5)
Microconidia size (µm)	5–7.5(–8) x 0.8–1	5–7.5(–8) x 0.8–1	5–8(–9) x (0.5–)0.7– 0.9
Pigments in apothecia and pycnidia	Sedifolia-grey; K+ violet, C+ violet or purple	No pigments	Sedifolia-grey; K+ violet, C+ violet or purple
Chemistry (TLC)	Methoxymicareic acid	Methoxymicareic acid	Micareic acid

**Table 1**, diagnostic features for the separation of *Micarea byssacea*, *M. micrococca s. stricto* (sensu Czarnota & Guzow- Krzemińska) and *M. prasina* based on the cited samples from North America and Europe, and Czarnota & Guzow-Krzemińska (2010).

*European Micarea prasina specimens examined for comparison:* – **FINLAND.** UUSIMAA: Kirkkonummi, Meiko Nature Reserve, *Vaccinium myrtillus* – *Picea abies* forest type, 26.v.2010, on xylem of decaying *Picea abies*, *A. Launis* 265101 (H). ETELÄ-HÄME: Hämeenlinna, Evo, Kotinen Nature Reserve, SW of lake Valkea-Kotinen, 22.ix.2010, on xylem of a dead standing *Pinus sylvestris*, *A. Launis* 229101 (H), *A. Launis* 229102 (H). POHJOIS-SAVO: Ahveninen, Sorsasalo, old forest nature reserve, SE from the lake Lyly, 19.ix.2010, on xylem of decayed conifer stump against rock wall, *A. Launis* 199105 (H). POHJOIS-KARJALA: Lieksa, Koli National Park, E slope of Koli, old natural forest, 5.ix.2013, on xylem of fallen *Picea abies*, *A. Launis* 59131 (H), *A. Launis* 89131 (H).

*Micarea micrococca specimens examined.* – **U.S.A. MAINE.** HANCOCK CO.: Donnell Pond Maine Public Reserve Land, Black Mt., Wizard lake in saddle just E of east Black Peak, mixed *Acer-Picea* forest surrounding *Thuja* swamp in narrow valley, 14.vi.2012, on bark of *Thuja occidentalis*, *A. Launis* 146127 (H).

*European Micarea micrococca specimens examined for comparison:* – **FINLAND.** UUSIMAA: Sipoo, Rörstrand old growth Forest Nature Reserve, S side of swamp Moraskärr, 29.ix.2010, on bark of shaded old *Alnus glutinosa*, *A. Launis* 299101 (H); Sipoo, Rörstrand old growth Forest Nature Reserve, just N from swamp Moraskärr, 23.viii.2013, on bark of shaded *Betula pubescens*, *A. Launis* 238131 (H); Korso, near border of Vantaa, *Picea abies* dominated mature managed forest, 12.x.2013, on bark of shaded *Picea abies*, *A. Launis* 1210131 (H), on xylem of

*Picea abies*, *A. Launis* 1210132 (H). VARSINAIS-SUOMI: Somero, Hossoja, grove, 10.ix.2011, on bark of an old *Betula pubescens*, near a small river, *A. Launis* 109111 (H).

### *Micarea hedlundii* Coppins

#### FIGURES 1D AND F.

CHARACTERIZATION OF THE SPECIMENS EXAMINED. Thallus effuse, olive-green, minutely granular, composed of small goniocysts containing  $\pm$  orange oil droplets (*Intrusa*-yellow; K+ violet, C+ violet). Photobiont micareoid (cells  $\pm$  globose, 4–7  $\mu$ m). Apothecia usually absent, sometimes numerous, immarginate and convex, often becoming tuberculate, 0.2–0.5 mm in diameter, brownish to dull brown, much resembling those of *M. prasina*. Hymenium hyaline often with irregular vertical streaks, epihymenium and vertical streaks in hymenium dilute straw-brown and K $\pm$  violet, C $\pm$  violet due to the presence of the *Sedifolia*-grey pigment, which is confined to the gel matrix. Hypothecium hyaline to yellowish. Ascus clavate. Ascospores ellipsoid, ovoid or oblong, 0–1 septate (6.5–)7.5–9(–12)  $\times$  (2.5–)3–4(–4.5)  $\mu$ m. Pycnidia stalked 0.2–0.5 mm tall, always present, pale, pinkish, lilac to grey-brown, covered with a white tomentum, pycnidial walls K $\pm$  violet, C $\pm$  violet (*Sedifolia*-grey pigment). Mesoconidia narrowly ellipsoid, 4–5.5(6)  $\times$  1.2–1.7  $\mu$ m.

CHEMISTRY. – No substances detected by TLC. The *Sedifolia*-grey and the *Intrusa*-yellow pigments detected by chemical spot tests (K and/or C).

DISTRIBUTION AND ECOLOGY. – *Micarea hedlundii* was first reported for North America by Gowan and Brodo (1988), based on a collection from New Brunswick, Canada. Since then, the species has been collected from California (B. Coppins pers. comm.), and from Maine (by the first author), Michigan (by W.R. Buck) and Quebec (by S. Clayden).

*Micarea hedlundii* is a strictly lignicolous species occurring on soft decaying wood of low pH, mainly of coniferous trees. It prefers old growth forests where it can be found on shaded and wet parts of horizontal trees or on vertical stumps near the mossy base or soil. An abundance of soft, decaying wood of stumps and fallen trees seem to be the main habitat requirement for the species.

NOTES. – *Micarea hedlundii* is probably more widespread in North America than the small number of known occurrences might indicate. Thalli can be inconspicuous and, therefore, rather challenging to find on the shaded parts of trunks and stumps. The stalked, brown to pinkish pycnidia with a white tomentum are characteristic and resemble only those of *M. tomentosa* Czarnota & Coppins, a rarer species known only from Central Europe and Sweden. When found growing with *M. prasina*, which has a similar thallus, *M. hedlundii* can be distinguished by its stalked tomentose pycnidia, darker colored olive green thallus and K+ purple-violet oily droplets (*Intrusa*-yellow pigment) that are found by careful microscopic examination of the goniocysts. The phylogenetic analyses by Czarnota and Guzow-Krzemińska (2010) show that *M. hedlundii* is closely related to *M. prasina*, *M. byssacea* and *M. micrococca*.

As in Europe, *Micarea hedlundii* is likely to be quite rare in North America because of its strict ecological preferences. In many European countries it is considered an indicator of environmental continuity and old-growth forests.

*Specimens examined.* – **U.S.A. MAINE.** WASHINGTON CO.: Town of Beals, Great Wass Island Reserve, humid mixed forest dominated by *Abies* spp., *Picea rubens*, *Betula cordifolia*, *Sorbus americana*, *Ilex* spp., 6.vi.2012, on decaying horizontal trunk of coniferous tree, *A. Launis* 66124 (NY), 6.vi.2012, on decaying base of vertical *Abies* sp., near mossy soil, *A. Launis* 66125 (H). **MICHIGAN.** CHEBOYGAN CO.: Reese's Bog, W of Roberts Road, 1 mi S of Riggsville Road (Hwy C64) on East Burt Lake Road and Roberts Road, *Thuja*-dominated swamp, 13.xii.2002, on decaying wood, *W.R. Buck* 42008 (NY), *Buck* 42018 (NY). **CANADA. QUEBEC.** MRC des Laurentides, Parc national du Mont-Tremblant, Sentier du Toit des Laurentides, near Ruisseau des Pruches, cool NE-facing slope with mixed forest dominated by *Abies balsamea*, *Betula alleghaniensis*, *Acer rubrum* and *Acer saccharum*, 26.ix.2009, on well-rotted stump of *Betula alleghaniensis*, *S. Clayden et al.* 20521 (NBM). **NEW BRUNSWICK.** ALBERT CO.: Fundy National Park, Marven Lake Trail ca. 0.5 km. west of Rat Tail Bar, 27.viii.1981, *S. Gowan et al.* 4504 (CANL).

*European specimens examined for comparison:* –**FINLAND.** VARSINAIS-SUOMI: Veijola, Mustamäki, SW-slope, *Picea abies* – dominated herb-rich heath forest, 21.vi.2009, on rotten stump, *J. Pykälä* 34470 (H). ETELÄ-HÄME: Hämeenlinna, Evo, Kotinen Nature Reserve, near lake Valkea-Kotinen, 6.vii.2011, on xylem of decaying vertical *Pinus sylvestris*, *A. Launis* 67119 (H), 15.x.2013, on stump of *Picea abies*, *A. Launis* 1510131. POHJOIS-

HÄME: Saarijärvi, Pyhä-Häkki National Park, ½ km S-SW of Mastomäki, *Picea abies* – dominated old-growth forest, 12.vii.2008, on stump of *Pinus sylvestris*, J. Pykälä 32808 & H. Hyvärinen (H). ETELÄ-SAVO: Joroinen, Sorsasalo Old Forest Nature Reserve, *Picea abies* – dominated forest, 10.ix.2010, on decaying stump of a conifer, A. Launis 109101 (H). POHJOIS-KARJALA: Lieksa, Koli National Park, E slope of Koli, old-growth forest, 5.ix.2013, on xylem of fallen *Picea abies*, A. Launis 59132 (H). KUUSAMO: Paljakka, E shore of river Kuusinkijoki, Kiukaankorva, *Picea abies* – dominated herb-rich forest, 5.viii.2009, on rotten stump, J. Pykälä 35708 (H). **NORWAY**. HEDMARK: Trysil, Jordet, Kaldevja ravine, 19.ix.2013, on rotten stump of *Picea abies* in old, humid spruce forest close to a brook, R. Haugan 11948 (O); Trysil, Jordet, Kaldevja ravine, 19.ix.2013, on rotten stump of *Picea abies* in old, humid spruce forest close to a brook, R. Haugan 11949 (O). OPPLAND: Gausdal, Auggedalen, Midtdalsbekken, rotten stump of *Picea abies*, humid spruce forest of tall herb type close to a brook, 25.ix.2013, R. Haugan 11840 (O).

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## Discovery of *Hypogymnia pulverata* on the Gaspésie Peninsula in eastern Canada

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AND STEPHEN R. CLAYDEN<sup>6</sup>

**ABSTRACT.** – *Hypogymnia pulverata* appears to be uncommon in North America. Previous collections are known from Alaska, Oregon, and near the coast of Hudson Bay in northwestern Québec. Here we report it from Mont Olivine and along the Rivière Sainte-Anne in Parc national de la Gaspésie, Québec. These occurrences are approximately 1,000 km southeast of the Hudson Bay locality, and extend the known range of *H. pulverata* to the Atlantic Coastal Region of eastern North America.

**KEYWORDS.** – Phytogeography, Tuckerman Workshop, rare, lichen.

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### INTRODUCTION

The genus *Hypogymnia* comprises a group of charismatic macrolichens that is particularly common and speciose in arctic and boreal regions of the northern and southern hemispheres (Elix 1979, Brodo et al. 2001, McCune 2008, Hansen & McCune 2010, Elvebakk 2011, Goward et al. 2012). Currently, thirty-eight species of *Hypogymnia* are known from North America (Miadlikowska 2011, Esslinger 2014). *Hypogymnia pulverata* (Nyl. ex Cromb.) Elix is the only member of the genus that consistently has a solid medulla (i.e., the lobes are solid rather than hollow, despite appearing inflated), lacks a pitted lower surface, and has laminal soredia (Figure 1).

Globally, *H. pulverata* has a widespread distribution that includes Australasia, China, eastern Russia, Japan, and South America (Rassadina 1971; Elix 1979, 1992; Elvebakk 2011). It appears to be uncommon in North America, where a single population was first encountered by Claude Roy and Robert Gauthier along the Hudson Bay coast in northwestern Québec (Brodo 1989). Later it was found along the coast of Oregon, again as a single population (McCune et al. 1997). More recently a number of populations were discovered in Alaska between 2004 and 2010 (Nelson et al. 2011). Considering the broad gap between its known occurrences in the Pacific and Hudson Bay coastal regions, we have long speculated that *H. pulverata* may also occur along the Atlantic Coast of northeastern North America. As such, it was gratifying to discover a population in Parc national de la Gaspésie on the Gaspésie Peninsula in Québec

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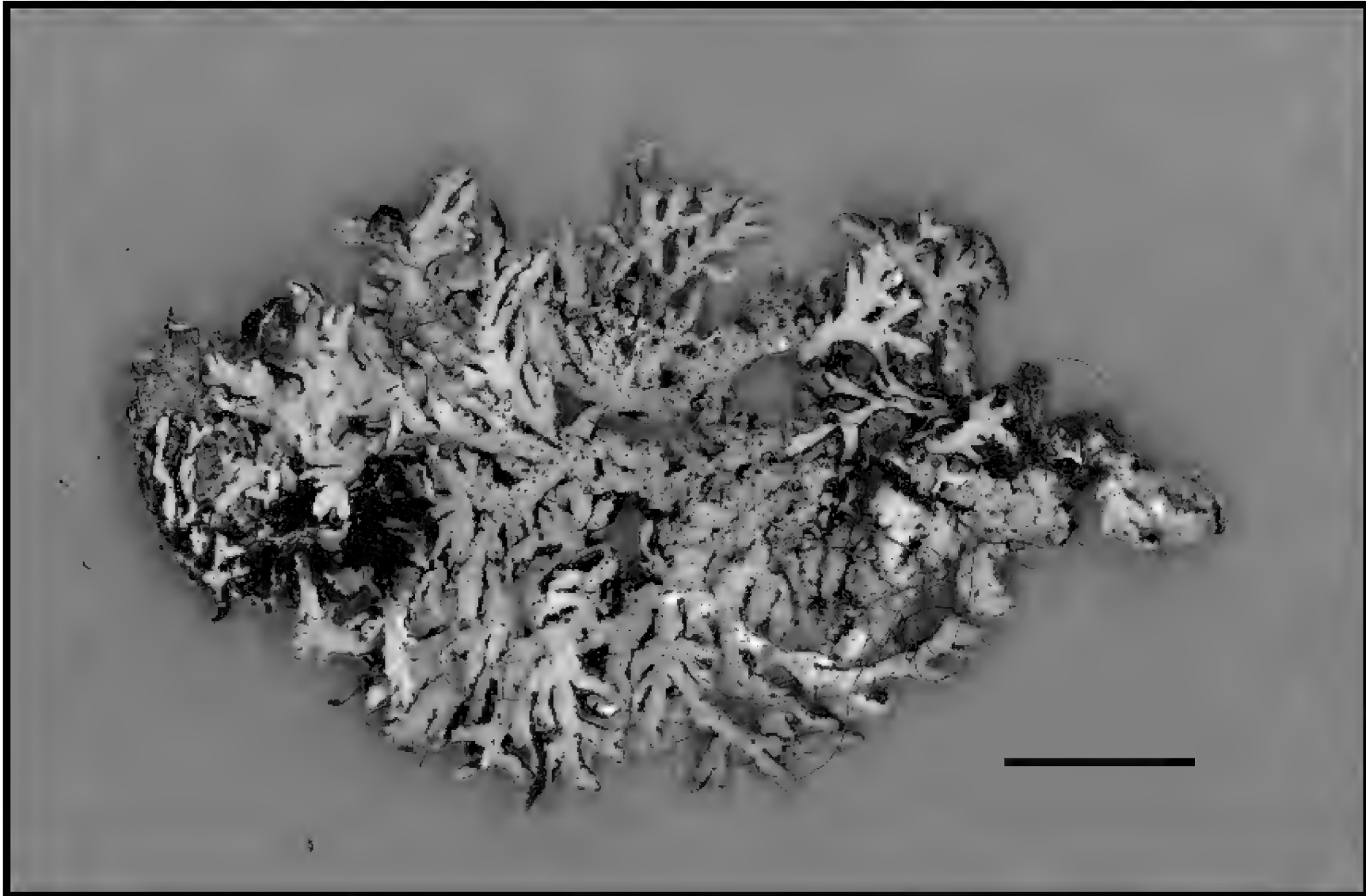
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**Figure 1,** *Hypogymnia pulverata* from Mont Olivine (Lendemer 32486, NY; scale = 1.0 cm).

during the 21<sup>st</sup> Tuckerman Workshop. We formally document this occurrence here, and extend the known distribution of *H. pulverata* in eastern North America by about 1,000 km to the southeast (Figure 2).

## MATERIALS AND METHODS

Specimens collected by the authors are deposited at the Canadian Museum of Nature (CANL), the Louis-Marie Herbarium at Laval University (QFA), the New Brunswick Museum (NBM), and the New York Botanical Garden (NY). Reference specimens of *Hypogymnia pulverata* deposited at NY were also used for comparison, as was a duplicate (at NBM) of the collection made by Claude Roy in northwestern Québec that was reported by Brodo (1989). Specimens were examined dry using standard dissecting and compound light microscope techniques. The chemistry of specimens was examined using the standard spot tests reagents outlined by Brodo et al. (2001) and some specimens were also examined with thin-layer chromatography (TLC) using solvent C as outlined by Lendemer (2011).

## RESULTS

All of the specimens we collected on the Gaspésie Peninsula were found in mature conifer forests on the southern slopes of Mont Olivine (Figure 3) or along the Rivière Sainte-Anne at the base of Mont Albert. They were collected from the bark of conifer trees or conifer snags. This habitat and substrate is consistent with the collections made in other parts of North America (Brodo 1989, McCune et al. 1997, Nelson et al. 2011). We observed at least ten individual thalli of the species on Mont Olivine, and it should be noted that the collections reported here were found independently by the collectors (i.e., the species is frequent enough at this locality to be located by multiple individuals searching a large area independently).

The specimens we collected all have a P+ red medulla, which is in accordance with the other specimens reported from North America, except for the P- one from Oregon (McCune et al. 1997). Our specimens that were examined with TLC contained atranorin and physodic, physodalic, and 3-hydroxyphysodic acids, which is the same result Brodo (1989) had when he examined the collection from northwestern Québec. Nelson et al. (2011) reported protocetraric acid in their specimens from Alaska, but



**Figure 2**, known geographic distribution of *Hypogymnia pulverata* in North America based on specimens examined for this study and those published by Brodo (1989), McCune et al. 1997 and Nelson et al. (2011).

they did not report any of the acids that were found in our specimens. Elix (1979) stated that the chemical causing the P+ red reaction is consistently physodalic acid and protocetraric acid is either present or absent. Our collections and the specimen from the other Québec location lack protocetraric acid (Brodo 1989), which agrees with the findings of Elix (1979). It was not stated if the collections from Alaska were examined with TLC (Nelson et al. 2011), so there may be other substances present in addition to protocetraric acid in that material.

*Specimens examined.* – **CANADA. QUÉBEC:** Gaspésie Peninsula, M.R.C. de la Haute-Gaspésie, Parc national de la Gaspésie – Mont Olivine, Mont Olivine trail, 48.88646°N, 66.1117°W, mixed conifer forest, 2.vii.2012, on a conifer snag, *R.C. Harris* 57555 (NY); Mont Olivine, trail to La Serpentine 0–2.5 km N of junction with the Mont Olivine trail, 48.8931°N, 66.1158°W, mixed wood forest (with *Abies*, *Acer*, *Betula*, *Larix*, *Ilex* and *Picea*) with serpentine and mafic outcrops, 2.vii.2012, on a snag, *J.C.*



**Figure 3**, habitat of *Hypogymnia pulverata* on Mont Olivine (top) and image of Roy & Gagnon 12-5990-C in the field (bottom).



*Lendemer 32486* (NY), on *Abies balsamea*, *J.C. Lendemer 32459* (NY); Mont Olivine, Mont Olivine trail, between the trail where it forks and the edge of the corridor for power transmission lines, 48.887222°N, 66.113611°W, in an *Abies-Picea* forest, 6.vii.2012, on *A. balsamea*, *C. Roy & J. Gagnon 12-5990-C* (NBM, QFA), *C. Roy & J. Gagnon 12-5993-C* (CANL, QFA); Rivière Sainte-Anne near look-off over Chute Sainte-Anne, 48.9404°N, 66.1241°W, forest of *A. balsamea* and *Thuja occidentalis* near falls, 3.vii.2012, on branch of *A. balsamea*, *S.R. Clayden 23173* (NBM).

## DISCUSSION

The remarkably scattered distribution of *Hypogymnia pulverata* in North America suggests that it may also occur between the locations that are presently known. Scattered distributions, however, are common in several other sorediate *Hypogymnia* species (Miadlikowska et al. 2011). Therefore, *H. pulverata* may in fact be a rare species, whose occurrence is restricted to coastal or other areas with a very humid climate.

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## Defining the range and habitats of *Enterographa oregonensis*

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**ABSTRACT.** – New information resulting from focused surveys for the recently described foliicolous lichen species *Enterographa oregonensis* is presented. Locations, substrates, and habitat preferences are described, and some observations regarding the geography of its abundance in coastal northern California and southern Oregon are reported.

**KEYWORDS.** – biogeography, Curry County, endemism, habitat modeling, Humboldt County, Mendocino County, *Phycopeltis*, Sonoma County.

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### INTRODUCTION

*Enterographa oregonensis* is a foliicolous lichen that was recently discovered and described by Sparrius and Björk (2008). At the time of its description it was known from two disjunct populations in hypermaritime locations, one in northern Oregon (Tillamook County) and another on the southwest shore of Vancouver Island in British Columbia. The small number of sites and the small areas (approximately 100m<sup>2</sup> at the type locality) occupied by the lichen caused the authors to discuss the possibility of conservation status for *E. oregonensis*.

*Enterographa oregonensis* is the only member of the genus known to occur north of central California (CNALH 2014, Tucker 2014). It has an obligate foliicolous habit (Spribille et al. 2009), and it is believed to be a western North American endemic. We acted on the suggestion by Sparrius and Björk (2008) that searches in northern California and Oregon might prove fruitful, with the results presented here. We have now completed coastal surveys from Curry County, Oregon to Monterey County, California, focusing on the potential habitat of *E. oregonensis*. In this paper we report locations, substrate and habitat preferences, and some notes regarding geographic abundance.

### MATERIALS AND METHODS

**Study Area:** The study area is the hypermaritime strip of coast between Curry County, Oregon in the north and Monterey County, California in the south. Within this area we targeted locations that met the criteria for general foliicolous lichen habitat based on Villella and Carlberg (2012): appropriate substrates, proximity to the coast, shelter from direct storm lash and direct precipitation, and moderate to heavy canopy closure. Surveys within this habitat were intuitively controlled (i.e. non-transect, non-random). Location, habitat, abundance and substrate notes were taken at each site and location coordinates recorded with handheld Garmin 62s GPS receivers. Specimens were later determined in the lab using standard lichen identification techniques (Brodo et al. 2001). Initial collections were confirmed by Curtis Björk and representative collections are deposited at OSC and in the personal herbaria of the authors.

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**Figure 1**, world distribution of *Enterographa oregonensis*. Green circles are from Villella and Carlberg (2012) and this paper; black diamonds are from Sparrius and Björk (2008). Solid line represents coastal range searched by Carlberg and Villella, dotted lines are counties and areas searched by Björk.

## RESULTS

*Geographic distribution.* – We initially found *Enterographa oregonensis* in California in 2011 on a Bureau of Land Management holding on the Samoa Peninsula in central Humboldt County (Ma-le'l Dunes). Additional surveys at Big Lagoon State Park in a species-rich foliicole community resulted in further detections of *E. oregonensis*. Other Humboldt County sites were Russ Park in Ferndale and Hiller Park in McKinleyville. Surveys in Mendocino County, California (Chadbourne Gulch, Mackerricher State Park campground, Russian Gulch State Park) produced new records of *E. oregonensis* on a variety of substrates, with increasing abundance (Figure 1). The southernmost known population is currently in Sonoma County, California, at Timber Gulch, a few kilometers south of Fort Ross State Historic Park.

We also had opportunities to visit areas of appropriate habitat at a few California locations south of Timber Gulch. These included Point Lobos State Reserve in Monterey County, Huckleberry Botanic Regional Preserve in Alameda County, and Muir Woods National Monument and Cataract Trail in the Marin Municipal Watershed District, both in Marin County. *Enterographa oregonensis* was not found at any of these locations.

To the north of Humboldt County we found *E. oregonensis* at Tolowa Dunes State Park in Del Norte County, California, and in southwest Oregon we encountered it at Collier H. Buffington Memorial Park in Gold Beach, in Curry County. An accounting of the voucher specimens for the occurrences reported here is provided below. The known distribution of the species is summarized in figure 1.

***Specimens examined:*** U.S.A. CALIFORNIA. DEL NORTE CO.: Tolowa Dunes State Park, 2011, on *Picea sitchensis* needles and *Vaccinium ovatum* leaves, *J. Villella s.n.* (hb. Villella). HUMBOLDT CO.: Ma-le'l Dunes Cooperative Management Area, in understory of dune forest, 2011, on *Vaccinium ovatum*, *J. Villella 11-10* (hb. Villella); Big Lagoon State Park, in campground, 2011, on understory *Polystichum munitum*, *J. Villella 11-18* (hb. Villella); Manila, Ma-le'l Dunes, 2011, on *Vaccinium ovatum* leaves, *T. Carlberg 02532* (OSC); Arcata, Ma-le'l North, 2012, on *Vaccinium ovatum* leaves, *T. Carlberg 02855* (hb. Carlberg); McKinleyville, Hiller Park, 2012, on *Picea sitchensis* needles, *T. Carlberg 03037* (hb. Carlberg); Manila, private property, 2012, on *Abies grandis* needles, *T. Carlberg 02843* (hb. Carlberg), and *Vaccinium ovatum* leaves, *T. Carlberg 02835* (hb. Carlberg); Ferndale, Russ Park, 2012, on *Abies grandis* needles and twigs, *T. Carlberg 03039* (hb. Carlberg), and *Picea sitchensis* needles, *T. Carlberg 03051* (hb. Carlberg). MENDOCINO CO.: Mackerricher State Park, Cleone Campground, 2012, on *Vaccinium ovatum* leaves, *T. Carlberg 02782* (hb. Carlberg), *J. Villella 12-68* (hb. Villella); Russian Gulch State Park, south of Russian Gulch Bridge, 2012, on *Abies grandis* needles, *T. Carlberg 02788A* (OSC), *T. Carlberg 02788B* (hb. Carlberg), *T. Carlberg 02789* (hb. Carlberg), *J. Villella 12-56* (hb. Villella). SONOMA CO.: Fort Ross State Historic Park, Fort Ross Creek, 2012, on *Torreya californica* needles, *T. Carlberg 03014* (hb. Carlberg); Fort Ross State Historic Park, Timber Gulch, 2012, on *Sequoia sempervirens* needles, *T. Carlberg 03007* (hb. Carlberg). OREGON. CURRY CO.: Collier H. Buffington Memorial Park in the city of Gold Beach, in undeveloped eastern portion of the park, 2012, on understory *Vaccinium ovatum* and *Abies grandis*, *J. Villella s.n.* (hb. Villella).

*Habitats.* – *Enterographa oregonensis* was found to be widespread and locally common in hypermaritime locations in this area (Figure 1). Most known locations for *E. oregonensis* from this study are in sheltered hypermaritime forests that are distanced from the immediate effects of coastal storms, typically at least 0.5 horizontal km from the mean high tide line, and with a forest buffer or topographic feature providing additional shelter. Most locations also are characterized as older forests, with either older, larger trees, or younger trees in forests with long stand continuity. Emergent canopy cover is typically 75-90%, and understory cover values are also often high. The exceptions to this are Russian Gulch State Park where the species grows on *Abies grandis* needles on the edges of coastal cliffs approximately 30 vertical m above the surf, and Chadbourne Gulch in Mendocino County that is located on an exposed steep north-facing road cut with scant cover of mid-mature *Alnus rubra* trees, within 0.4 km of the ocean.

Understory vegetation at occupied sites is typically composed of *Garrya elliptica*, *Gaultheria shallon*, *Polystichum munitum* and *Vaccinium ovatum*. Overstory in the northerly counties is *Picea sitchensis* and *Pinus contorta* var. *contorta*, or a more mixed conifer forest of *Abies grandis*, *Picea sitchensis*, *Pinus contorta* var. *contorta*, and *Pseudotsuga menziesii*. *Picea sitchensis* reaches the southern limit of its range near the town of Mendocino, and while the Fort Ross and Timber Gulch sites had a typical understory, the dominant trees in the canopy were *Sequoia sempervirens* and *Pseudotsuga menziesii*, with occasional *Torreya californica*.



**Figure 2,** *Enterographa oregonensis* growing over needles of *Abies grandis* at Mackerricher State Park. Photograph © Stephen Sharnoff and reproduced herein with permission.

*Substrates.* – The following are substrates for *Enterographa oregonensis*: leaflets of senescing *Polystichum munitum* fronds, *Sequoia sempervirens* needles, *Torreya californica* needles, *Abies grandis* needles and adjacent twigs, *Vaccinium ovatum* leaves, and *Picea sitchensis* needles and adjacent twigs. The predominant substrates, accounting for 85% of our collections, are *Picea sitchensis* (35%), *Vaccinium ovatum* (31%) and *Abies grandis* (19%). The remaining collections are from *Polystichum munitum*, *Sequoia sempervirens* and *Torreya californica*. Substrates can be as little as six months of age.

*Abundance.* – *Enterographa oregonensis* was found to be widespread and locally common in hypermaritime locations growing in the foliicolous crustose lichen community typical of the Pacific Northwest coast. Associated species include *Fellhanera bouteillei*, apparently undescribed species of *Scoliosporum* (Ekman, pers. comm. in Miller et al. 2011; Villella & Carlberg 2011) and *Opegrapha* (Villella & Carlberg 2011, in consultation with C. Björk), *Byssoloma* cf. *marginatum*, and *Byssoloma* cf. *subdiscordans*. We found no apparent nutrient enrichment requirements as noted for the more northern populations (Sparrius & Björk 2008).

Populations are often extensive with many thousands of thalli observed at most locations. At all sites in the south of the study area, *Enterographa oregonensis* was easily located. At Mackerricher State Park, where the understory in the campground is approximately 80% *Vaccinium ovatum*, *E. oregonensis* is by far the most abundant lichen present, covering approximately 35% of the available substrate (Figure 2).

## DISCUSSION

A characteristic of temperate foliicolous lichen communities found in western North America is that they are made up mostly of facultative foliicoles with few obligately foliicolous species (Daubenmire 1943, Miller et al. 2011, Spribille et al. 2009, Villella & Carlberg 2011). Most species in these communities



are also found to grow as bark epiphytes, on wood, or even on rocks (Rhoades 2009). This is a pattern seen in other defined temperate foliicole lichenogeographic regions such as the Valdivian, Tethyan and Neozealandic-Tasmanian regions (Lücking 2008), whereas in tropical settings facultative foliicoles are rare (Santesson 1952). *Enterographa oregonensis* differs from this general pattern, being an obligate foliicolous species within this temperate community (Spribille et al. 2009).

Species of *Enterographa* are abundant among tropical foliicolous lichen communities (Lücking 2008) where the genus exhibits a very high degree of regional species endemism (Lücking & Kalb 2001). *E. oregonensis* follows a similar pattern as a regional endemic in our comparatively species-depauperate phyllosphere community. Other temperate regions also have endemic foliicolous *Enterographa* species, such as *E. falcata* from the Valdivian rainforest region of southwestern South America (Lücking 2008).

The foliicole community in temperate northwest North America is seen to develop rapidly (Villella & Carlberg 2011) and in many cases can completely cover the leaves upon which it is growing (Figure 2). While there appears to be little to no literature available on the longevity of these sclerophyll substrates, the temperate foliicolous lichen communities growing on them are thought to be short lived (Daubenmire 1943) and in contrast to many other lichens, foliicolous species become fertile very quickly (Daubenmire 1943, Santesson 1952, Spribille et al. 2009). Our experience with *Enterographa oregonensis* bears this out. Completion of its life cycle (recruitment, maturation and spore dispersal) must outpace the decay or drop of its supporting substrate. We observed this with the appearance of incipient thalli that are apparently *E. oregonensis* growing on foliage only a few months old. We also observed free living thalli of *Phycopeltis* within the first few months of foliar emergence, and thalli of *E. oregonensis* are fully developed sometimes as early as one year after foliar emergence.

It is possible that *Enterographa oregonensis* is a strict hyper-coastal species because its photobiont is restricted to hypermaritime areas. *Phycopeltis* is a widespread and common tropical and sub-tropical epiphytic trentepohlioid alga (Graham et al. 2009). As a lichen photobiont it is restricted to typically foliicolous species (Lücking 2008). There are also two species of *Phycopeltis* known from temperate Europe in areas such as permanently wet woodlands in southwestern Ireland (Rindi & Guiry 2002), and stream side areas in southern Spain (Rindi et al. 2004). In the Pacific Ocean region records for free-living *Phycopeltis* come from the Hawaiian Islands where there are at least two species (Sherwood 2004), and the islands of Samoa with at least five species (Guiry 2014). Many tropical and subtropical species of lichens that reach the northern edge of their range in northern California, often as small disjunct populations, have trentepohlioid photobionts, and *Phycopeltis* containing lichens seem to be restricted to hypercoastal areas.

It is possible to explain the absence of *Enterographa oregonensis*, and of a foliicolous lichen community in general, from the coastal strip of Marin and southern Sonoma counties by the lack of appropriate substrates. *Baccharis pilularis* is a common coastal shrub in central California, but in our experience it has no apparent capacity to serve as a substrate for foliicolous lichens; the same applies to species of *Arctostaphylos*, *Notholithocarpus densiflorus*, and *Quercus agrifolia*. In addition, sheltered coastal forested areas become rare in central and southern California, where chaparral dominates. In this region *Sequoia sempervirens* and *Pseudotsuga menziesii* are scant or absent, restricted to narrow canyons of the short coastal rivers. *Picea sitchensis* grows no further south than the town of Mendocino, and while *Torreya californica* extends south to Monterey County, it is widely scattered throughout its range (Howard 1992). Along the Pacific Coast *Abies grandis* occurs from southern British Columbia south to Sonoma County (Howard & Aleksoff 2000). It may be fruitful to explore the mixed *Sequoia sempervirens*/*Pseudotsuga menziesii* forests in the creek and river canyons of the Big Sur area.

It is also possible to explain the absence of *Enterographa oregonensis* from Point Lobos and Huckleberry Preserve by the exposure to coastal storms and lack of adequate canopy cover, respectively. However, only the factor of distance from the coast (approximately 4.0 km) might explain the absence of *E. oregonensis* from the moist Cataract Creek drainage in Marin County, where a dense canopy of *Pseudotsuga menziesii*, *Sequoia sempervirens*, *Umbellularia californica*, and *Notholithocarpus densiflorus* grows above a dense understory that includes *Vaccinium ovatum* and *Polystichum munitum*.

One other *Enterographa* species is known to occur in California (Tucker 2014). *Enterographa anguinella* (Weber 1306; SBBG) was collected as a bark epiphyte by W. A. Weber in Monterey County in 1959; this collection was determined by S. Tucker in 2010 (CNALH 2014). At this time *Enterographa oregonensis* is not known to occur sympatrically with *E. anguinella* in California.

Given the specificity of habitat and substrate, the authors suggest that *Enterographa oregonensis* is an excellent candidate for habitat modeling, especially a model that uses meteorological variables. If the climatic parameters are as narrow as those already found for geography and substrate, a model may prove

to be highly accurate. While our findings indicate that the range and abundance of *E. oregonensis* is far greater than the initial assessment by Sparrius and Björk (2008), and thus appear to warrant no status in an occurrence-based conservation system, the highly specific niche (hypercoastal strip) it occupies is arguably the most imperiled habitat in California, and local extirpation becomes a realistic concern. Preliminary surveys on the Oregon coast indicate that it quickly becomes more rare to the north and conservation status may be warranted in Oregon, Washington, and perhaps British Columbia.

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# Lichens and lichenicolous fungi of Grasslands National Park (Saskatchewan, Canada)

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**ABSTRACT.** – A total of 194 lichens and 23 lichenicolous fungi are reported. New for North America: *Rinodina venostana* and *Tremella christiansenii*. New for Canada and Saskatchewan: *Acarospora rosulata*, *Caloplaca decipiens*, *C. lignicola*, *C. pratensis*, *Candelariella aggregata*, *C. antennaria*, *Cercidospora lobothealliae*, *Endocarpon loscosii*, *Endococcus oreinae*, *Fulgensia subbracteata*, *Heteropladidium zamenhofianum*, *Lichenocodium lichenicola*, *Placidium californicum*, *Polysporina pusilla*, *Rhizocarpon renneri*, *Rinodina juniperina*, *R. lobulata*, *R. luridata*, *R. parasitica*, *R. straussii*, *Stigidium squamariae*, *Verrucaria bernaicensis*, *V. fusca*, *V. inficiens*, *V. othmarii*, *V. sphaerospora* and *Xanthoparmelia camtschadalis*. New for Saskatchewan alone: *Acarospora stapfiana*, *Arthonia glebosa*, *A. epiphyscia*, *A. molendoi*, *Blennothallia crispa*, *Caloplaca arenaria*, *C. chrysophthalma*, *C. citrina*, *C. grimmiae*, *C. microphyllina*, *Candelariella efflorescens*, *C. rosulans*, *Diplotomma venustum*, *Heteropladidium compactum*, *Intralichen christiansenii*, *Lecanora valesiaca*, *Lecidea atrobrunnea*, *Lecidella wulfenii*, *Lichenodiplis lecanorae*, *Lichenostigma cosmopolites*, *Lobotheallia praeradiosa*, *Micarea incrassata*, *M. misella*, *Physcia alnophila*, *P. dimidiata*, *Physciella chloantha*, *Polycoccum clauzadei*, *Polysporina subfuscenscens*, *P. urceolata*, *Rhizocarpon viridiatrum*, *Rinodina conradii*, *Sarcogyne hypophaea*, *S. similis*, *Sphaerellothecium cladoniae*, *Staurothele monicae*, *Taeniolella rolffii*, *Tetramelas pulverulentus*, *Xanthomendoza fulva*, *Xanthoparmelia loxodes*, *X. subdecipiens* and *Zwackhiomyces coepulonus*. Fifteen species are rare in the Park and of these *Caloplaca lignicola*, *Rinodina juniperina*, *R. luridata*, *R. parasitica*, *R. straussii* and *R. venostana* are quite likely rare in Canada, as well. Comments on selected species and a key for the *Heteropladidium* and *Verrucaria* species in the Park are provided.

**KEYWORDS.** – Great Plains, Prairies Ecozone, Mixed Grassland Ecoregion.

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## INTRODUCTION

Lichens are an easily observed but underappreciated feature of Grasslands National Park. This is the first attempt to compile a list of the lichens of the Park. The aim of the study is to raise awareness of lichens as a part of the biodiversity of the Park, inform park management policies and practices as they affect the lichen biota, and to contribute to our knowledge of the lichen flora of Saskatchewan and Canada.

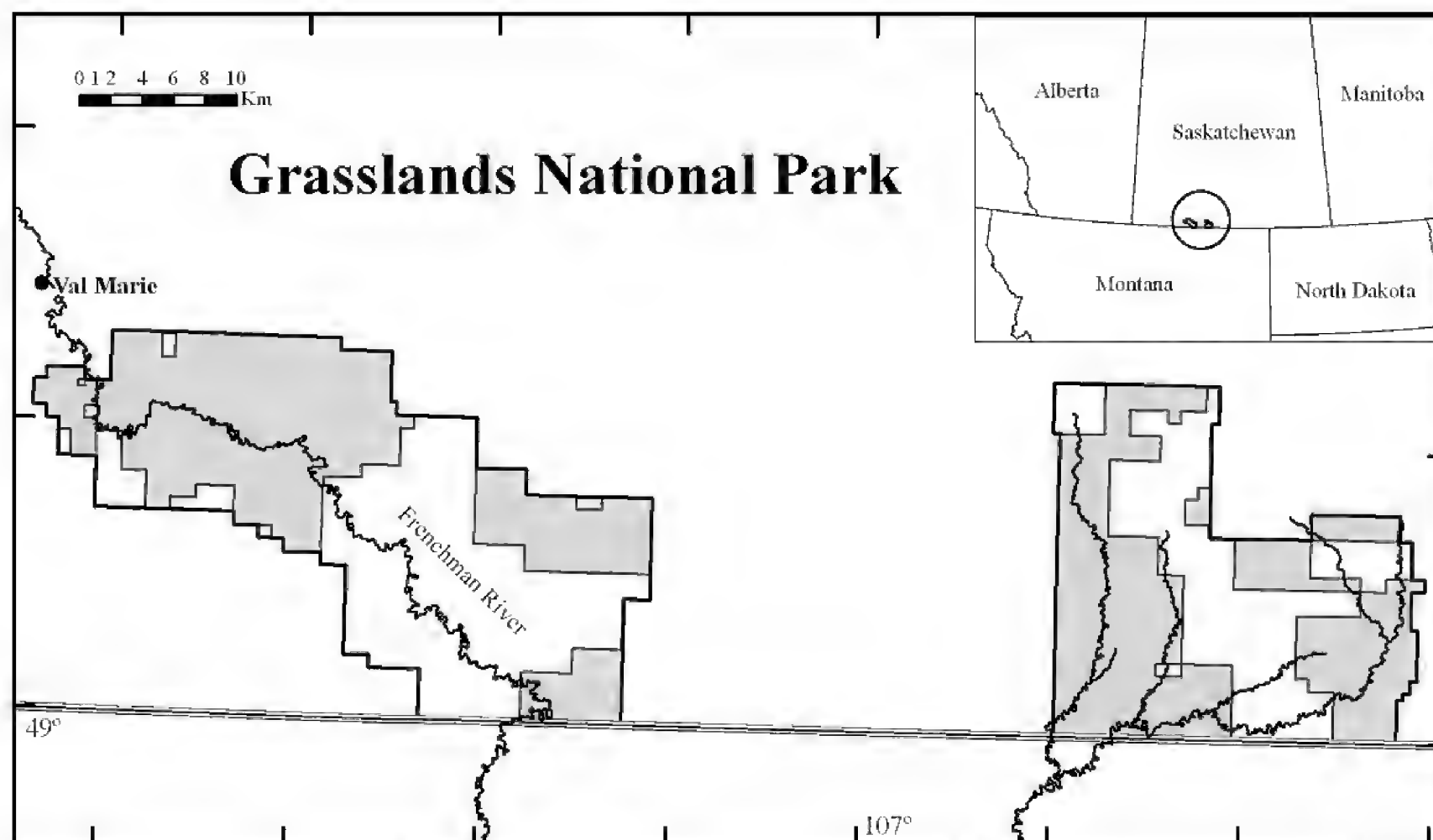
Previous reports on the lichens of southern Saskatchewan include Looman (1962, 1964) and Macoun (1902). A vegetation survey prepared as part of the process of establishing Grasslands National Park (Michalsky & Ellis 1994) made but a brief reference to “abundant terricolous lichens.” Three reports referring to individual species collected in the Park are noted below. The Saskatchewan Conservation Data Centre maintains lists of lichen species for the province (De Vries 2011).

## MATERIALS AND METHODS

Eight visits to Grasslands National Park of approximately five days each were made between 2008 and 2013. Initially, exploratory visits were made to all major landforms and botanical communities (Fargey

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**Figure 1**, location of the study area and an outline of proposed boundaries. Shaded areas show holdings as of 2012. Note that the East Block water shed is largely seasonal; only the easternmost branch, Rock Creek, is a permanent water source.

et al. 2000, Michalsky & Ellis 1994), after which research efforts focussed on habitats that appeared to have the highest potential for lichen diversity. Some localities were visited more than once to obtain better quality specimens and to take advantage of better collecting conditions. Examples of all lichen species were collected from each locality, with the exception of the most common species.

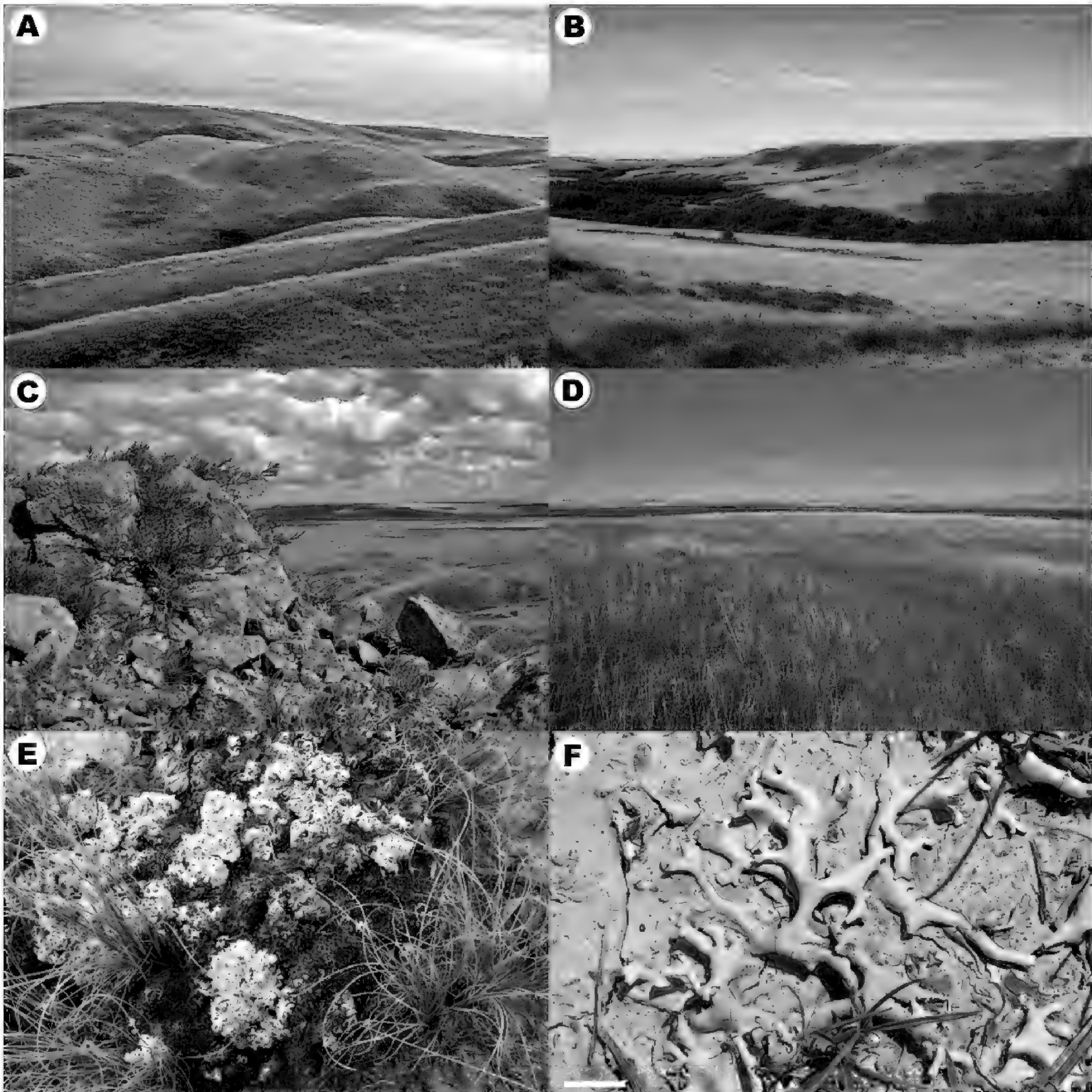
Specimens were examined using a Wild M5 stereomicroscope and a Wild M20 compound microscope. Hand-cut sections of ascocarps were studied in water and/or with the addition of a 10% solution of potassium hydroxide (K). Polarised lenses were used to detect crystals in apothecial sections. A 0.5% Lugol's solution (I) following pretreatment with K was used for the detection of amyloid reactions in ascus tips. Spot tests were conducted with K, household bleach (C) and a saturated alcohol solution of *para*-phenylenediamine (P). Chemical analyses were made with the assistance of Irwin M. Brodo, using the thin-layer chromatographic (TLC) methods of Culberson (1972) and subsequent modifications summarized in Orange et al. (2001). Determinations were also aided by comparisons with the extensive and diverse collections kept at the National Lichen Herbarium of Canada (CANL). Selected specimens were determined by specialists.

The following documentation and websites were particularly helpful in making determinations: Bird (1970), Brodo (2011), Brodo et al. (2001), Culberson et al. (2011), McCune and Rosentreter (2007), Nash III et al. (2002, 2004, 2007), Sheard (2010), Smith et al. (2009), Thomson (1984, 1997), Wetmore (1967) and Wirth (1995). Primary literature resources for the determination of lichenicolous fungi included Diederich (1996, 2004), Hawksworth (1979, 1981, 1983), and Ihlen and Wedin (2008). Previous lichen records were researched in Bird (1972), Brodo (2012), Brodo et al. (2001), De Vries (2011), Esslinger (2014), Looman (1962, 1964), and Marsh (2010). An extensive literature search was conducted for previous records of lichenicolous fungi, which resulted in the production of a database organized by province and territory, and by parasite-host relationship (Freebury in prep.). Botanical nomenclature follows Esslinger (2014), excluding the incomplete taxonomic revisions to the family Teloschistaceae proposed in Arup et al. (2013). Vouchers are deposited at CANL.

## THE STUDY AREA

Grasslands National Park (Figure 1) is located in the extreme south of Saskatchewan on the Canadian border with the United States. At the time of the study the Park comprised 571 of a total proposed





**Figure 2**, habitats in Grasslands National Park. A, grassland slopes in the Two Trees Area. B, wooded valley and grassland plateau in the Wood Mountain Uplands. C, crumbling rock outcrop on 70 Mile Butte, with the Frenchman River Valley in the distance. D, short-grass prairie along the Three Sisters Trail. E, *Buellia elegans* growing over *Placidium squamulosum* on an eroded grassland slope. F, *Xanthoparmelia chlorochroa* growing attached to soil (scale bar = 1.0 cm).

921 km<sup>2</sup> of land divided into two blocks approximately 27 km apart (Parks Canada 2007). The Park was officially established as a national park under the new Canada National Parks Act on February 19, 2001.

The Park comprises a tiny remnant of the once extensive Mixed Grassland Ecoregion, which lies within the Prairies Ecozone, a northern extension of the Great Plains of North America (Shorthouse 2010, Wiken 1986). The physical geography is characterized by grassland plains, rolling hills, coulees, badlands, mudflats, river grasslands and wooded uplands (figure 2). Most of the Park was and remains uncultivated ranch land. Mean elevation ranges between 776 meters and 920 meters above sea level. The climate is semi-arid and features abundant sunshine, frequent high winds, and relatively cold winters and hot summers. From 1961 until 1990 the mean annual precipitation was 312.5 mm, 29% of which fell as snow. Daily mean temperatures during this period ranged from -13° C in January to +18.7° C in July (Environment Canada 2011).

Within the two subunits (“blocks”) of the Park, the main collection localities were as follows.

West Block:

- Two Trees Area. Grassland slopes, mixed grasses (*Bouteloua gracilis* and *Hesperostipa comata*), abundant *Selaginella densa* (hereafter referred to as *Selaginella*) and *Phlox hoodii*, widely scattered glacial till and several large piles of rock taken from long-abandoned grain fields. Within 1.5 km north, east and south of the Two Trees landmark at 49°11'N, 107°42'W, elev. 796–843 m.
- Syrenne Ranch. *Ulmus pumila*-*Caragana arborescens* (*Ulmus* and *Caragana*, respectively) windbreak close to an abandoned ranch house at the foot of grassland slopes, *Salix amygdaloides* (*Salix*) along periodically flooded oxbows. 49°10'N, 107°41'W, elev. 789 m.
- Three Sisters Trail. Grassland plateau and steep, gravel-strewn, north-facing grassland slopes with *Juniperus horizontalis* (*Juniperus*). 49°08'N, 107°38'W, elev. 836–858 m.
- 70 Mile Butte and Eagle Butte Area. Badlands with mudrock outcrops, mossy north-facing slopes with abundant *Juniperus*. Within 1.3 km north and west of 70 Mile Butte. 49°11'N, 107°39'W, elev. 823–917 m.
- Ecotour Plateau. Mixed-grass plateau with scattered glacial till, gravel washouts at the base of steep coulee slopes, and a prairie dog colony. Within 2.5 km south of the park entrance. 49°13'N, 107°33'W, elev. 842–863 m.
- Frenchman River Valley. Saline mudflats with patches of bare soil, short grasses, eroded stream banks, scattered *Sarcobatus vermiculatus* (*Sarcobatus*) and *Artemisia cana* (*Artemisia*), abandoned wooden ranch structures and a prairie dog colony. 49°10'22.30"N, 107°33'16.50"W to 49°07'37.07"N, 107°28'37.96"W, elev. 779–772 m.
- North Gillespie Trail. Mixed-grass plateau, deep coulees, isolated thickets, barren ridges with *Sarcobatus* and *Krascheninnikovia lanata* (*Krascheninnikovia*) and scattered glacial till on eroded slopes. 49°05'N, 107°15'W, elev. 882–902 m.

East Block:

- Killdeer Badlands. Eroded buttes, wooded coulees with abundant *Fraxinus pennsylvanica* (*Fraxinus*), isolated calcareous outcrops and mixed-grass plateaus. Within 4 km west and southwest of the park entrance at Poverty Ridge at 49°01'N, 106°31'W, elev. 906–954 m.
- McGowan Homestead Area. Grassland plateau, valley grassland, mudflats, isolated mudrock outcrops in steep bluffs on the west side of Rock Creek, gravely washouts, and *Sarcobatus* and *Krascheninnikovia* on eroded slopes. Within 2 km of the East Block visitor centre. 49°04'N, 106°31'W, elev. 845–897 m.
- Lockhart Ranch Area. Grassland plateau; rock-strewn, short-grass slopes; and an *Ulmus*-*Caragana* windbreak. 49°02'N, 106°53'W, elev. 804–816 m.
- Lowell Homestead Area. Grassland plateau and slopes; valleys with stands of *Populus tremuloides* (*Populus*), *Prunus virginiana* (*Prunus*) and *Crataegus rotundifolia* (*Crataegus*); seasonal springs and occasional outcrops and gravelly ridges. Along a road to 5 km south of the park boundary. 49°11'N, 106°46'W, elev. 915–1000 m.
- Wood Mountain Uplands. Grassland plateau, *Populus* forests and seasonal springs. 49°12'N, 106°42'W, elev. 906–954 m.

## RESULTS

A total of 194 lichens and 23 lichenicolous fungi are here reported from the study area. Of these, *Rinodina venostana* and *Tremella christiansenii* are reported for the first time from North America, while 27 species are newly reported for Canada and Saskatchewan and another 41 are newly reported for Saskatchewan alone. Fifteen species were found only once or twice during the course of this study and are therefore thought to be rare in the Park: *Caloplaca lignicola*, *Candelaria concolor*, *Cladonia botrytes*, *C. cristatella*, *Physcia aipolia*, *P. alnophila*, *P. dimidiata*, *Rinodina conradii*, *R. juniperina*, *R. luridata*, *R. parasitica*, *R. straussii*, *R. venostana*, *Sarcogyne magnussonii* (locally abundant) and *Xanthomendoza fulva*. Of these, *Caloplaca lignicola*, *Rinodina juniperina*, *R. luridata*, *R. parasitica*, *R. straussii* and *R. venostana* might also be rare in Canada due to the limited availability of appropriate substrates (i.e., decaying wood and crumbling sandstone). Range extensions are reported for *Caloplaca lignicola*, *C. pratensis*, *Physcia alnophila*, *Rinodina juniperina*, *R. lobulata*, *R. luridata*, *R. parasitica* and *R. straussii*, all but one of which

are known from the Great Plains in the USA and could be expected to be found in the Park. The exception is *Physcia alnophila*, which is a southern boreal and arctic species; although it was reported from the Cypress Hills in Alberta, it is not otherwise known from the Great Plains (Brodo et al. 2013).

Only one lichen reported here, *Circinaria hispida* (syn. *Aspicilia hispida*), is included on the current list of rare lichens of Canada (Goward et al. 1998). However, the species is common and widespread throughout the Park.

Macrolichens (foliose and fruticose species) comprise only 35% (68/194) of the lichen taxa reported for the Park compared with an average of 50% (2609/5205) in eleven other North American study areas (Spribille et al. 2010). In the study area, macrolichens are typically poorly formed, which is likely related to the semi-arid climate and the eroding effects of wind-blown soil and snow. Microlichens (crustose and squamulose species), at 64% of the total species-level diversity of lichens found, seem better suited for prevailing environmental conditions. Interestingly, microlichens comprise virtually the same proportion (65% and 66%, respectively) of the lichen floras of the American Arctic (Thomson 1984, 1997) and Badlands National Park, South Dakota (Will-Wolf 1998).

The most lichen-rich areas of the Park are the short-grass slopes of the Frenchman River Valley. This is likely due to the variety of substrates and favourable angles of exposure to the sun. Species found on these slopes included: *Acarospora schleicheri*, *Amandinea punctata*, *Arthonia glebosa*, *Blennothallia crispa*, *Buellia elegans*, *Caloplaca crenulatella*, *C. stillicidiorum*, *C. tirolensis*, *C. tominii*, *Candelariella aggregata*, *Cetraria aculeata*, *Circinaria hispida*, *Cladonia pocillum*, *C. robbinsii*, *C. symphylicarpa*, *Collema tenax*, *Dimelaena oreina*, *Diploschistes muscorum*, *Endocarpon pusillum*, *Fulgensia bracteata*, *F. subbracteata*, *Lecanora garovaglii*, *Lecidea atrobrunnea*, *Lecidea tessellata*, *Lecidella stigmatea*, *Lobothallia alphoplaca*, *Ochrolechia upsaliensis*, *Phaeorrhiza sareptana*, *Physconia muscigena*, *Placidium squamulosum*, *Psora cerebriformis*, *P. decipiens*, *Rhizocarpon renneri*, *Rhizoplaca chryssoleuca*, *R. melanophthalma*, *Rinodina terrestris*, *Toninia sedifolia*, *Xanthoparmelia chlorochroa*, *X. subdecipiens*, *X. wyomingica* and *Xanthoria elegans*. Many of these species were also found elsewhere in the Park but less abundantly, notably on gravelly hill tops and in short-grass areas of the Rock Creek, Jackknife Point and Poverty Ridge uplands.

Abandoned grain fields in the region have been extensively colonized by invasive grasses to the exclusion of native species. *Selaginella*, the dominant biological cover on nearby undisturbed land and a significant substrate for a wide diversity of lichens, is completely absent. One such field in the Two Trees Area was abandoned in 1984 and remains devoid of terricolous and muscicolous lichens. The only species found at that site were a very few poorly formed thalli of *Lecanora hagenii* and *Xanthoria elegans* on small rocks.

Following below this section are annotated lists of the lichens and of lichenicolous fungi found during the inventory of the study area. The lichen list includes species that are parasitic on other lichens but have lichenized thalli. The list of lichenicolous fungi includes only true lichenicolous fungi, that is, fungi parasitic on lichens and which never become lichenized. Representative specimens are cited for each taxon and those which were examined by specialists are underlined. Collection numbers are those of the author unless otherwise indicated. A triple asterisk (\*\*\*) indicates the species is new to North America; a double asterisk (\*\*) indicates new to Canada and Saskatchewan; and a single asterisk (\*) indicates new to Saskatchewan alone.

A key is provided at Appendix A as an aid to distinguishing between the nine relatively inconspicuous and superficially similar *Heteroplacidium* and *Verrucaria* species that are reported here.

## CHECKLIST OF LICHENS

*Acarospora americana* H. Magn. (syn. *Acarospora superfusa* H. Magn.) – On acidic rock. 859, 999, 1560 (det. Knudsen). Knudsen et al. (2011) and Lendemer and Knudsen (2011) cited collection 859.

*Acarospora badiofusca* (Nyl.) Th. Fr. – On calcareous rock. 1024A (sub *Lecanora* cf. *muralis*), 2076.

*Acarospora glaucocarpa* (Ach.) Körber – On calcareous rock. 983A, 1560, 2023, 2036 (det. Knudsen).

\*\**Acarospora rosulata* (Th. Fr.) H. Magn. – On acidic rock. 529, 1263, 1366, 2010 (det. Knudsen).

*Acarospora schleicheri* (Ach.) A. Massal. – Terricolous on eroded grassland slopes and badlands. 557, 583, 585.

\**Acarospora stapfiana* (Müll. Arg.) Hue – Often found parasitic on *Caloplaca trachyphylla*, occasionally independent on rock. 919A, 1264.

*Acarospora strigata* (Nyl.) Jatta – On calcareous rock. 970, 1696, 1877, 1774.



- Acarospora veronensis* A. Massal. – On acidic rock. 891A, 1371.
- Agonimia* cf. *vouauxii* (B. de Lesd.) M. Brand & Diederich – On mossy soil. 545. Thallus minutely squamulose; cortical cells papillate; perithecia superficial, subspherical, 0.20 mm in diameter; involucrellum absent; hymenial gel I+ orange/red; asci 2-spored; ascospores hyaline, strongly muriform,  $52\text{--}62 \times 20\text{--}32 \mu\text{m}$ , ellipsoid. Looks rather typical for *A. vouauxii*, although the spores are slightly shorter and broader than the measurements given by Sérusiaux et al. (1999):  $(40\text{--})60\text{--}72(-87) \times 15\text{--}24(-31) \mu\text{m}$ , narrowly ellipsoid (P. Diederich, pers. comm., 01 July 2012).
- Amandinea punctata* (Hoffm.) Coppins & Scheid. – On organic detritus, shrubs and wood. 457A, 1004, 1620, 1853 (det. Sheard).
- \**Arthonia glebosa* Tuck. – On soil. 495.
- Arthonia patellulata* Nyl. – On *Populus*. 1859, 1933, 1571.
- Aspicilia cinerea* (L.) Körber – On mossy shingles. 2054, 1925. Usually a saxicolous species that is seldom if ever reported on wood.
- Aspicilia* cf. *determinata* (H. Magn.) N.S. Golubk. – On calcareous sandstone. 977A, 983C. This taxon is referable to *A. determinata*, based on comparison with the morphology of the type from Asia and unpublished molecular studies (Owe-Larsson, pers. comm., 11 Dec. 2012).
- Aspicilia* sp. 01 – On siliceous rock. 839, 847C, 964, 1383A. Thallus areolate, K–, olive-brown, mottled white; areoles contiguous; prothallus distinct, yellow to blue-grey, fimbriate; apothecia 1 per areole; disc black, flat, epruinose; margins concolorous with thallus; epihymenium olive green; hymenium  $100\text{--}160 \mu\text{m}$  tall; asci 8-spored; ascospores simple, subglobose,  $(15.6\text{--})18.4\text{--}21.4 \times 10.7\text{--}13.8(-15.3) \mu\text{m}$ .
- Aspicilia* sp. 02 – On siliceous rock. 451. Thallus areolate, K+ red, dark blue-grey; areoles flat, contiguous, sub-radiate; prothallus distinct, dark, sub-fimbriate; apothecia 1 to 4 per areole; disc black, slightly immersed; thalline margin prominent, inner edge white; epihymenium blue-black; hymenium  $153 \mu\text{m}$  high; asci 8-spored; ascospores simple,  $23\text{--}23.6 \times 10.7\text{--}13.8 \mu\text{m}$ .
- Bacidia bagliettoana* (A. Massal. & De Not.) Jatta – On moss on steep, north-facing slopes and in uplands forest. 509, 913B, 1285, 1292, 1867.
- Bacidia circumspecta* (Nyl. ex Vainio) Malme – Corticolous on *Populus* base in forest next to spring. 1934.
- Bilimbia sabuletorum* (Schreber) Arnold – Musicolous on *Populus* base. 1277, 1935.
- Bryoria fuscescens* (Gyelnik) Brodo & D. Hawksw. – On *Juniperus*. 917, 880A, 1766.
- \**Blennothallia crispa* (Hudson) Otálora, P.M. Jørg. & Wedin (syn. *Collema crispum* (Hudson) Weber ex F.H. Wigg.) – On mossy soil on eroded slopes and as part of *Selaginella*-dominated turf in the open prairie. 1040, 1286, 1641, 1793 (det. Björk).
- Buellia elegans* Poelt – On soil and over terricolous lichens such as *Fulgensia bracteata*, *Phaeorrhiza sareptana* and *Placidium squamulosum* (Fig. 2-E). 574, 818B. TLC: atranorin and norstictic acid (trace), which corresponds to chemotype I of Trinkaus & Mayrhofer (2000).
- Caeruleum heppii* (Nägeli ex Körber) K. Knudsen & L. Arcadia – On calcareous rock. 1051, 1257, 1698, 1717.
- \**Caloplaca arenaria* (Pers.) Müll. Arg. – On siliceous rock and occasionally on worked, hard wood. 1354, 1388, 1624, 1798, 1852. Apothecia 0.5 mm in diameter, disc rusty-orange, margins rusty-red, ascospores  $13.5\text{--}15.0 \times 4.0\text{--}5.0 \mu\text{m}$ , septum  $1.0\text{--}2.0 \mu\text{m}$  wide,  $n=11$ . *Caloplaca fraudans* as reported from Saskatchewan in Looman (1962) is most likely *C. arenaria*. *Caloplaca fraudans* is a littoral species with broader apothecia ( $0.4\text{--}2 \text{ mm}$ ) and wider spore septa ( $2.5\text{--}4.5 \mu\text{m}$ .) than *C. arenaria* (Arup 1995).
- Caloplaca atroalba* (Tuck.) Zahlbr. – On soft, calcareous rock. 544, 834, 976, 1661 (det. Wetmore).
- Caloplaca cerina* (Hedw.) Th. Fr. – On *Populus* in the Rock Creek Area. 834, 931 1324; all sub *Phoma caloplacae*.
- \**Caloplaca chrysophthalma* Degel. – On *Juniperus*. 913C, 1579 (det. Brodo).
- \**Caloplaca citrina* (Hoffm.) Th. Fr. – On exposed calcareous rock. 873, 1756, 1812, 996. This species was also found in abundance on concrete sidewalks in Mankota, ca. 32 km northwest of the East Block. It corresponds well to *C. citrina* s. str. as defined by Arup (2006).
- Caloplaca crenulatella* (Nyl.) H. Olivier s. lat. – On calcareous rock, often associated with *Rinodina bischoffii*. 472, 820, 1259, 1674, 1780. The material matches the descriptions for *C. crenulatella* provided in Fletcher and Laundon (2009), Navarro-Rosinés & Hladun (1996) and Wetmore (2007). However, the exact circumscription of this species is unclear and further analysis is required to resolve apparent molecular differences within the group (Vondrák et al. 2011).



- \*\**Caloplaca decipiens*** (Arnold) Blomb. & Forssell – On acidic and calcareous sandstone. 968, 1634, 1783, 1880. This lichen can often be seen from distances of up to 1 km on rocks protruding from clay embankments along Rock Creek.
- \**Caloplaca grimmiae*** (Nyl.) H. Olivier – Lichenicolous on *Candelariella vitellina*. 1320, 1847. Thallus barely discernible.
- Caloplaca holocarpa* (Ach.) A.E. Wade – On low-lying, eutrophicated shrubs and occasionally on rock. 519, 1953, 2081.
- \*\**Caloplaca lignicola*** Wetmore – Lignicolous on abandoned ranch buildings. 1619, 1627 (det. Wetmore). This lichen appears to be rare in the Park. It is reported here as a northern range extension from Minnesota, Montana and North Dakota (Wetmore 2009).
- \**Caloplaca microphyllina*** (Tuck.) Hasse – On lignum. 935, 1583, 1618, 1742, 2056. This species is common on old fences and abandoned granaries, schools and farm houses throughout much of the southern parts of Saskatchewan but does not appear to have been reported for the province previously.
- \*\**Caloplaca pratensis*** Wetmore – On calcareous outcrops. 870B, 972B, 1053, 1701 (det. Wetmore). Previously reported from Montana, North Dakota and further south in the Great Plains (Wetmore 2009).
- Caloplaca pyracea* (Ach.) Th. Fr. (sensu Arup 2009) – On *Artemisia*, *Fraxinus*, *Populus*, *Salix* and *Ulmus*. 942, 1282, 1778, 1906.
- Caloplaca stillicidiorum* (Vahl) Lynge s. lat. – On *Artemisia*, detritus and bone. 522, 536D, 552, 1601, 1665, 1725. This material matches the description of the fourth of six provisional ecotypes in the unresolved group described by Šoun et al. (2011). Associated species: *Amandinea punctata*, *Caloplaca holocarpa*, *Candelariella aggregata*, *C. antennaria*, *Lecanora hagenii*, *Rinodina pyrina*, *R. terrestris* and *Xanthomendoza montana*.
- Caloplaca tirolensis* Zahlbr. – On dead *Selaginella* and detritus. 806, 813, 1610, 1617, 2075, 2091.
- Caloplaca tominii* (Savic) Ahlner – Terricolous on saline mudflats in the Frenchman River Valley and in prairie dog colonies. 1614, 1663, 2001, 2010 (det. Vondrák). Areoles/squamules with marginal or laminal corticate granules 60–100 µm in diameter rather than soredia as described in Arup (2006), Vondrák et al. (2011) and Wetmore (2001).
- Caloplaca trachyphylla* (Tuck.) Zahlbr. – On acidic and calcareous rock. 565B, 919A, 1264.
- Candelaria concolor* (Dickson) Stein – On dead branches in coulee thickets. This species is rare in the Park; it was found but twice and in poor condition. 1805, 1825.
- \*\**Candelariella aggregata*** M. Westb. – On dead *Selaginella* and detritus. 458, 770, 821, 906C, 1008.
- \*\**Candelariella antennaria*** Räsänen – On *Populus* snags, *Artemisia*, *Ulmus* and *Krascheninnikovia*. 793, 1704, 1737, 1834, 2084.
- Candelariella aurella* (Hoffm.) Zahlbr. – On calcareous rock and bone. 871B, 1258, 1362, 1850, 1879.
- \**Candelariella efflorescens*** R.C. Harris & W.R. Buck – On *Crataegus*, *Fraxinus* and *Juniperus*. 992, 1541, 1720, 1869. For descriptions of this species and distribution patterns, refer to Brodo et al. (2001), Lendemer and Westberg (2010) and Westberg (2007).
- \**Candelariella rosulans*** (Müll. Arg.) Zahlbr. – On acidic rock. 481, 504, 1049, 1381. Thallus comprised of scattered or crowded convex areoles ca. 0.5 mm in diameter and becoming slightly lobate and incised.
- Candelariella vitellina* (Hoffm.) Müll. Arg. – On siliceous rock and wood. 1320, 1358, 1582, 1683, 1740, 1768, 1843.
- Cetraria aculeata* (Schreber) Fr. – On soil. *Cetraria aculeata* has an erratic (i.e., facultatively vagrant) growth form. It was usually found unattached over soil or entwined in ground vegetation in shallow depressions in the prairie. 493, 848D, 1801.
- Cetraria arenaria* Kärnefelt – Erratic over soil or turf in the Rock Creek Plain. 848C, 874.
- Circinaria* cf. *arida* Owe-Larss., A. Nordin & Tibell – On siliceous rock on grassland slopes, often growing from the level of the soil up the sides of smooth stones and pebbles, and frequently associated with *Circinaria hispida* and *Circinaria* sp. 01. Also collected twice on wood. 854, 1014, 1554, 1626, 1671, 1759. Areoles hemispherical, olive-brown, K–; prothallus present; hymenium I+ blue; paraphyses submoniliform; asci 4-spored; ascospores simple, broadly ellipsoid to subglobose, 17.5–27.5 × 16–22.5 µm; conidia filiform, 5.0×1.0 µm. TLC: aspililn. This taxon is referable to *C. arida*, although that species usually lacks a prothallus (Owe-Larsson et al. 2011).

- Circinaria contorta* (Hoffm.) A. Nordin, S. Savić & Tibell (syn. *Aspicilia contorta* (Hoffm.) Kremp.) – On sandstone in Wood Mountain Uplands. 1873, 1891. TLC: aspicilin.
- Circinaria hispida* (Mereschk.) A. Nordin, S. Savić & Tibell (syn. *Aspicilia hispida* Mereschk.) – Erratic over soil on mudflats, badlands and grassland slopes. 465, 532, 555, 851A, 909.
- Circinaria* sp. 01 – On detritus and soil. 804, 901C, 906A, 955, 1028, 1612, 1670, 2007. TLC (804, 901C, 1612, 2007): aspicilin (three specimens) or without aspicilin (one specimen), +/- unknown fatty acids (trace). Thallus recumbent fruticose to crustose, grey, mottled white; areoles lumpy, fused, contorted, often stringy and attached to detritus; apothecia poorly formed; spores not observed; conidia filiform, 8–10 × ca. 1.0 µm. Often associated with *Circinaria* cf. *arida* and *C. hispida* on grassland slopes. Unpublished molecular studies suggest that this is probably a new species but that further work is needed (B. Owe-Larsson, pers. comm., 11 Dec. 2012).
- Circinaria* sp. 02 – Terricolous in prairie dog colony. 581C, 1664, 1665 (sub *Endocarpon loscosii*), 1667, 1672. Thallus effigurate, 1.0–1.5 cm. in diameter, grey-green, mottled white, continuous becoming areolate; areoles adnate, contiguous, angular to rounded, slightly convex; lower surface with rhizohyphae and infrequent, pale rhizines. Not developing adhesions to adjacent detritus. Neither apothecia nor pycnidia observed. TLC (1665): no substances detected.
- Circinaria* sp. 03 – On detritus and soil. 1700. Thallus warty, recumbent fruticose, grey-green, mottled white; areoles narrow, contorted, fused, covered with small, pruinose warts; pycnidia one or more per wart; conidia bacilliform, 8–10 × ca. 1.0 µm. Apothecia not observed. TLC: aspicilin, unknown fatty acids. Resembles *Aspicilia* sp. as illustrated and briefly described in McCune and Rosentreter (2007).
- Cladonia arbuscula* subsp. *mitis* (Sandst.) Ruoss – Terricolous over short grass and *Selaginella* on the Rock Creek Plain. 1042, 1952.
- Cladonia botrytes* (K.G. Hagen) Willd. – On mossy logs in the Wood Mountain Uplands. This species was found only twice. 950, 1310.
- Cladonia cariosa* (Ach.) Sprengel – Terricolous as part of *Selaginella*-dominated turf. 1327.
- Cladonia chlorophaea* (Flörke ex Sommerf.) Sprengel – On detritus in badland thickets and on mossy logs in *Populus* forests. 953, 1310, 1639.
- Cladonia coniocraea* (Flörke) Sprengel – On mossy logs in *Populus* forests. 947, 1291, 1348, 1938.
- Cladonia cristatella* Tuck. – On wood in the Wood Mountain Uplands. This lichen was found once. 948.
- Cladonia fimbriata* (L.) Fr. – On mossy soil, rotting logs and detritus. 955, 1306, 1349, 1639.
- Cladonia gracilis* subsp. *turbinata* (Ach.) Ahti – On logs in *Populus* forests. 1300, 1311.
- Cladonia pocillum* (Ach.) O.J. Rich – A common component of *Selaginella* turf on sloped and upland grasslands throughout the Park. 511, 549, 994, 2026.
- Cladonia pyxidata* (L.) Hoffm. – On soil among *Selaginella* in the Jackknife Point Area. 998B.
- Cladonia rei* Schaerer – Terricolous among grass on Wood Mountain plateau. Poorly formed. 962, 998A (det. Ahti).
- Cladonia robbinsii* A. Evans – Terricolous among ground vegetation on sloped and upland grasslands. 507, 547.
- Cladonia symphycarpa* (Flörke) Fr. – Terricolous, often part of *Selaginella*-dominated turf. 206, 1021, 1278, 1358, 1868. TLC: atranorin and psoromic acid, which corresponds to chemotype 4 as described by Ahti et al. (2013).
- Collema tenax* (Sw.) Ach. – On exposed soil. 561, 761A, 1578, 1677, 2019.
- Cyphelium notarisii* (Tul.) Blomb. & Forssell – On fence posts and *Juniperus*. 537, 1035, 1353, 2055.
- Dimelaena oreina* (Ach.) Norman – On acidic rock on grassland slopes and hilltops. 847B, 1046, 2034A, 2046. TLC: usnic and gyrophoric acids; specimen 485: usnic acid alone. These specimens represent chemotypes II and III, respectively, of Mayrhofer and Sheard (2004).
- Diploschistes muscorum* (Scop.) R. Sant. – Parasitic on *Cladonia* spp. when young, unattached over soil when mature. 577, 791, 848E, 2016.
- \**Diplotomma venustum* (Körber) Körber – On calcareous rock. 567, 898, 912C, 1602.
- Enchylium coccophorum* (Tuck.) Otálora, P.M. Jørg. & Wedin (syn. *Collema coccophorum* Tuck.) – On soil in badlands and in ditches. 921, 1678, 2077 (det. Björk).
- \*\**Endocarpon loscosii* Müll. Arg. – On soil in prairie dog colonies. 1670, 1672, 1673, 1675. Lower surface pale; rhizohyphae hyaline; rhizines infrequent, pale; asci bisporous, narrowly clavate, 70–90 × 20–30 µm; ascospores 40–52 × 14–19 (proximal), 30–40 × 17.5–23 (distal), n=21. In comparison, *E.*

- pusillum* has a distinctive black lower surface and black, stubby rhizines. For descriptions of these two species and distinguishing features, refer to Breuss (2002a).
- Endocarpon pusillum* Hedwig – Terricolous on buttes, eroded slopes and prairie dog colonies. 571, 830, 1695, 2020.
- Evernia mesomorpha* Nyl. – On *Crataegus*, *Juniperus* and wood. 882, 1280, 1809, 1870.
- Fulgensia bracteata* (Hoffm.) Räsänen – Terricolous on eroded grassland slopes. 484A.
- \*\**Fulgensia subbracteata* (Nyl.) Poelt – Terricolous on eroded patches on grassland slopes in the Two Trees Area. 816C, 902, 907A. *Fulgensia fulgens* reported by Looman (1964) for Saskatchewan was probably *F. subbracteata*; at least one of the collections on which that determination was likely made has been so annotated (*Looman T808*, CANL!, annotated by C.M. Wetmore).
- Heppia lutosa* (Ach.) Nyl. – Terricolous on eroded grassland slopes. 1678.
- \**Heteropladidium compactum* (A. Massal.) Gueidan & Cl. Roux (syn. *Verrucaria compacta* (A. Massal.) Jatta) – On calcareous rock and partly parasitic on *Verrucaria inficiens*. 1335 (det. Breuss).
- \*\**Heteropladidium zamenhofianum* (Clauzade & Cl. Roux) Cl. Roux (syn. *Verrucaria zamenhofiana* Clauzade & Cl. Roux) – Initially parasitic on *Staurothele drummondii*, then independent on calcareous rock. 969, 1600 (det. Breuss).
- Hypogymnia physodes* (L.) Nyl. – On *Juniperus* on slopes in badlands and on logs in dry *Populus* forests. 919B, 1279, 1305, 1823.
- Lecania cyrtella* (Ach.) Th. Fr. – On *Fraxinus* and *Populus*. 952B, 989. Macoun (1902) reported this taxon from “Assiniboia” (i.e., Saskatchewan) as *Biatora cyrtella* (Ach.) W. Mann (*Macoun 2788* CANL!).
- Lecania fuscella* (Schaerer) Körber – On eutrophicated *Krascheninnikovia*. 1581, 1826, 1829, 2080.
- Lecanora albellula* Nyl. – On fence posts, corrals and dead *Ulmus*. 1005, 1011, 1538, 1910, 1731. TLC: isousnic acid.
- Lecanora argopholis* (Ach.) Ach. – On acidic rock. 822A, 1261, 1598, 2043.
- Lecanora flowersiana* H. Magn. – On limestone and sandstone; also collected once on *Juniperus*. 867, 912B, 1254, 1784, 1894, 2023. Apothecial discs epruinose or finely pruinose, as compared to *Lecanora crenulata* Hook. which has dense, coarse, crystalline pruina. For detailed descriptions of the distinguishing features of these two species, refer to Ryan et al. (2004) and Śliwa (2007).
- Lecanora garovaglii* (Körber) Zahlbr. – On siliceous rock and calcareous sandstone, and occasionally on hard wood. 526, 540B, 768, 1018, 1361, 1625, 1883.
- Lecanora hagenii* (Ach.) Ach. – On wood, bark, bone and detritus. 792A, 1039, 1546, 1569, 1736, 1833.
- Lecanora impudens* Degel. – On *Populus*. 1936. Thallus greyish white, thin, continuous; prothallus absent; apothecia absent; soralia roundish, discrete becoming confluent, slightly convex to excavate, never hemispherical; soredia greenish white. TLC: atranorin, triterpenoids. By comparison, *Lecanora allophana* f. *sorediata* has distinctly hemispherical soralia and lacks excavate soralia. See discussion in Brodo (1984) and Lendemer et al. (2013).
- Lecanora* cf. *muralis* (Schreber) Rabenh. – On calcareous rock. 1024A. Thallus placodioid, 3.5 cm in diameter; upper surface yellow-brown, appearing blue-grey due to dense pruina; areoles irregular, contiguous; lobes 2.0–3.0 mm long, flat, slightly folded along sinuses, concave and darkened at apices; cortex even; medulla solid. Apothecia abundant, crowded centrally; disk brown, epruinose; margins prominent, concolorous with thallus, pruinose; epihymenium brown, granular; hymenium hyaline, 61.2 µm tall, interspersed with fine POL+ granules; paraphyses narrow, unbranched; hypothecium hyaline; exciple hyaline, with hyphal bundles extending into algal layer below; algal cells filling amphithegium; thalline margin distinct, outer edge POL+ granular. Asci 8-spored, *Lecanora*-type; ascospores simple, ellipsoid, hyaline, 11.6–14.0 × 5.5–6.1 µm. All spot tests negative. TLC: usnic acid (trace), zeorin, leucotylin, triterpenes (running below norstictic). This specimen is referred to *Lecanora muralis*, described by Ryan et al. (2004) as an extremely variable taxon and a likely complex of species, based on its gross morphology and chemistry. It might otherwise key to *Lecanora valesiaca*, but that species appears yellowish, has smaller spores, contains roccellic acid and lacks triterpenes.
- Lecanora rugosella* Zahlbr. (sensu Brodo 1984) – On *Fraxinus* and *Juniperus*. 990, 993, 1550.
- \**Lecanora valesiaca* (Müll. Arg.) Stizenb. – On calcareous sandstone. 787, 1362. TLC: usnic acid and roccellic acid.
- Lecanora zosterae* (Ach.) Nyl. – On wood and on moss over sandstone. 1580, 1787B, 517A. TLC: no lichen substances detected.

- \**Lecidea atrobrunnea* (Lam. & DC.) Schaerer – On acidic rock. 847A, 1016, 1380. TLC: 2'-O-methylperlatolic acid.
- Lecidea auriculata* Th. Fr. – On acidic rock. 844, 1375, 1820, 2005.
- Lecidea tessellata* Flörke – On acidic rock. 528, 556, 1017, 1360, 1942.
- Lecidella euphorea* (Flörke) Hertel – On trees, shrubs, wood and detritus. 513A, 958, 1346, 1840.
- Lecidella patavina* (A. Massal.) Knoph & Leuckert – On calcareous and acidic rock. 560, 1019, 1822, 1887, 2033.
- Lecidella stigmathea* (Ach.) Hertel & Leuckert – On calcareous and acidic rock. 1318, 2031.
- \**Lecidella wulfenii* (Hepp) Körber – On mossy soil. 453A.
- Leptogium* cf. *nanum* Herre – On mossy soil. 1277 (det. Björk).
- Lobothallia alphoplaca* (Wahlenb.) Hafellner – On acidic rock. 464, 569, 1045.
- \**Lobothallia praeradiosa* (Nyl.) Hafellner – On acidic rock and sandstone. 1822, 1876, 1898.
- Megaspora verrucosa* (Ach.) Hafellner & V. Wirth – On organic detritus on short-grass prairie. 856, 1033, 1373, 2091.
- Melanelixia albertana* (Ahti) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch – On logs in *Populus* forests. 940A. TLC: lecanoric acid.
- Melanohalea elegantula* (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch – Corticolous on *Juniperus* and *Fraxinus* and lignicolous on logs. 951, 1638, 1855.
- Melanohalea exasperatula* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch – On *Juniperus* in the Eagle Butte Area. 1273, 1290.
- Melanohalea subolivacea* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch – On *Crataegus* and *Fraxinus*. 981, 1539, 1343, 1871.
- \**Micarea incrassata* Hedl. – On mossy soil on grassland slopes. 1545, 1575.
- \**Micarea misella* (Nyl.) Hedl. – On logs in *Populus* forests. 946, 1574.
- Montanelia tominii* (Oxner) Divakar, A. Crespo, Wedin & Essl. (syn. *Melanelia tominii* (Oxner) Essl.) – On acidic rock on the Ecotour Plateau. 1351, 1386.
- Ochrolechia upsaliensis* (L.) Massal. – On detritus on sloped and upland grasslands. 496A, 853A.
- Parmelia sulcata* Taylor – On *Juniperus* in badlands. 880, 918, 1288.
- Parmeliopsis ambigua* (Wulfen) Nyl. – On logs in *Populus* forests. 943, 954.
- Peltigera didactyla* (With.) J.R. Laundon – On exposed, mossy soil, especially near road cuts; as part of *Selaginella*-dominated turf on open prairie; and once on mossy wood 545, 848A, 1308, 1930, 1838. Lobes 4.0 to 7.0 mm in diameter, deeply concave and isolated from one another; rhizines simple and pointed, occasionally tufted and confluent. All specimens observed were sterile and sorediate. TLC: without lichen substances. A similar species, *Peltigera extenuata*, usually grows over mosses in lowland boreal and montane forests. Its lobes are typically abundantly branched and overlapping, and its rhizines are usually densely branched to fibrillose (Goffinet and Hastings 1995). *P. extenuata* often contains gyrophorate and gyrophoric acid, which are typically but not always absent from *P. didactyla* (Goffinet et al. 2003).
- Peltigera lepidophora* (Nyl. ex Vainio) Bitter – On mossy soil on the Rock Creek Plain and in the Wood Mountain Uplands. 1323, 1939.
- Peltigera ponojensis* Gyelnik – On moss in dry forests, and over grass and moss on grasslands. 952A, 1020, 1309, 1587. Lobes lightly tomentose, to 8.0 mm wide; rhizines simple or fibrous, discrete, to 3.0 mm long.
- Peltigera rufescens* (Weiss) Humb. – Terricolous in the Wood Mountain Uplands and in the Three Sisters Area. 1589, 1595. Lobes heavily tomentose, to 0.30 mm wide; rhizines tufted and confluent, ca. 0.1 mm long.
- Phaeophyscia constipata* (Norrlin & Nyl.) Moberg – On soil and over moss and detritus on grassland slopes and in badlands. 903A, 878, 1547, 1608, 2072.
- Phaeophyscia hirsuta* (Mereschk.) Essl. – On *Fraxinus*, *Ulmus* and calcareous sandstone. 1265, 1861.
- Phaeophyscia nigricans* (Flörke) Moberg – On *Fraxinus*, *Ulmus* and calcareous rock. 456, 518A, 973, 1706. Both narrow- and broad-lobed forms present. Lobe tips with tiny cortical hairs, as noted in Esslinger (2004).
- Phaeophyscia orbicularis* (Necker) Moberg – On *Artemisia*, *Fraxinus*, *Populus* and *Salix*. 1268, 1313, 1748, 1860, 1914, 1920.
- Phaeorrhiza sareptana* (Tomin) H. Mayrhofer & Poelt – On soil on eroded slopes. 572, 776, 832, 1613.



- Physcia adscendens* (Fr.) H. Olivier – On trees, shrubs and wood. This species was common but usually poorly formed and/or lacerated. 508E, 536A, 1708, 1767.
- Physcia aipolia* (Ehrh. ex Humb.) Fűrnr. – On *Juniperus*. This species was found only once. 1284.
- \**Physcia alnophila* (Vain.) Loht., Moberg, Myllys & Tehler – On *Ulmus*. This species was found only once. It is typically a southern boreal to arctic species (Brodo et al. 2013). 1255. TLC: atranorin, zeorin, no fatty acids or triterpenes.
- Physcia caesia* (Hoffm.) Fűrnr. – On calcareous and acidic rock. 842, 963, 1319, 1367.
- \**Physcia dimidiata* (Arnold) Nyl. – On *Ulmus*. This lichen was found only once. 1710.
- Physcia dubia* (Hoffm.) Lettau – On acidic rock and collected once on *Juniperus*. 1355, 1364, 1370, 1543.
- Physcia stellaris* (L.) Nyl. – On *Artemisia*, *Caragana*, *Fraxinus*, *Juniperus*, *Populus*, *Prunus*, *Salix*, *Ulmus* and wood. 1301, 1715, 1748, 1770, 1727, 1818 (det. Moberg). *Physcia stellaris* is variable in thallus pruinescence, the shape of lobe tips and the number of apothecia, which are usually abundant but can be as few as one or two.
- \**Physciella chloantha* (Ach.) Essl. – On *Caragana*, *Ulmus* and *Salix*. 1251, 1269, 1713, 1733.
- Physconia muscigena* (Ach.) Poelt – On soil, detritus and moss, and occasionally on *Juniperus*. 575, 1026, 1275, 1542, 1577.
- Physconia perisidiosa* (Erichsen) Moberg – On *Fraxinus*. 989.
- \*\**Placidium californicum* Breuss – Terricolous in sandy ditch. 2078 (conf. Breuss). Collected once but likely overlooked due to inconspicuous appearance. The distribution as presently known includes California (Breuss 2002b), Oregon, New Mexico and the Yukon (O. Breuss, pers. comm., 30 Sept. 2013).
- Placidium squamulosum* (Ach.) Breuss – Terricolous on eroded grassland slopes. 559A, 807, 907B, 1331, 1688.
- Polysporina simplex* (Taylor) Vězda – On acidic rock. 558C, 819.
- \**Polysporina urceolata* (Anzi) Brodo – On soft, calcareous rock. 579.
- Porpidia crustulata* (Ach.) Hertel & Knoph – On acidic rock. 843.
- Psora cerebriiformis* W.A. Weber – Terricolous on eroded, sloped grassland in the Two Trees Area. 570, 769, 837.
- Psora decipiens* (Hedwig) Hoffm. – Terricolous in badlands and on eroded grassland slopes and hilltops. 573E, 899, 1330, 1372.
- Psora tuckermanii* R.A. Anderson ex Timdal – On soil between cracks of calcareous rock. 892, 1334, 1633, 1874.
- Rhizocarpon disporum* (Nägeli ex Hepp) Müll. Arg. – On acidic rock. 489, 492, 1013, 1047, 1332, 2034B.
- \*\**Rhizocarpon renneri* Poelt – Lichenicolous on *Dimelaena oreina* and possibly lichenized on acidic rock. 2031.
- \**Rhizocarpon viridiatrum* (Wulfen) Körb. – Lichenicolous on *Aspicilia* and cf. *Circinaria* and lichenized on acidic rock and sandstone when mature. 808, 860, 910, 1387, 1800, 2090. Medulla I+ faint blue; ascospores sub-muriform with 3–5 cells visible in optical section.
- Rhizoplaca chrysoleuca* (Sm.) Zopf – On acidic rock and occasional on hard lignum. 473, 540D, 568B.
- Rhizoplaca melanophthalma* (DC.) Leuckert & Poelt – On acidic rock. The erratic morphotype of this species (Brodo et al. 2001, Thomson 1997) was not observed. 1009.
- Rinodina bischoffii* (Hepp) A. Massal. – On calcareous rock. 541C, 810, 979D, 1052, 1333 (det. Sheard).
- \**Rinodina conradii* Körber – On moss on badlands slope. This species was found only once. 1274.
- Rinodina freyi* H. Magn. – On *Juniperus*. 1549, 1638 (conf. Sheard).
- \*\**Rinodina juniperina* Sheard – Lignicolous on abandoned ranch buildings. 1267 (det. Sheard). Thallus poorly developed; discs mostly convex. This species was found but once. It was previously reported from North Dakota and further south in the Great Plains and in the Sonoran Desert (Sheard 2010).
- \*\**Rinodina lobulata* H. Mayrhofer & Sheard – On *Krascheninnikovia* on mostly barren badland slopes and ridges. 1036A, 1955 (det. Sheard). A northern range extension from North Dakota and Idaho (Sheard 2010).
- \*\**Rinodina luridata* (Körber) H. Mayrhofer, Scheidegger & Sheard – On a calcareous outcrop in the Wood Mountain Uplands. 1890, 1900. *R. luridata* was found only twice and in one location. It was previously reported from Colorado, North Dakota and Washington, as well as further south in the Sonoran Desert and coastal California (Sheard 2010). The only other species with such small

- Bicincta*-type spores is *R. ochracea* from the High Arctic (J. Sheard, pers. comm. 12 November 2012).
- \*\**Rinodina parasitica*** H. Mayrhofer & Poelt – On sandstone in a coulee in the Killdeer Badlands. 1789 (det. Sheard). *R. parasitica* was found but once in only one location. The species is also known to be lichenicolous on crustose lichens. It was previously reported from Alaska, Colorado, South Dakota, the American Pacific coast and the Sonoran Desert (Sheard 2010).
- Rinodina pyrina* (Ach.) Arnold – On bark and wood. 824, 929, 1741, 1769, 1819, 1922 (det. Sheard).
- \*\**Rinodina straussii*** J. Steiner – On calcareous rock on 70 Mile Butte. 558B, 566B, 1636 (det. Sheard). This species was found only three times in one location. This is a northern range extension from Idaho and Wyoming (Sheard 2010).
- Rinodina terrestris* Tomin – On soil, detritus and mosses. 561B, 581B, 806, 876, 893, 1548 (det. Sheard).
- \*\*\**Rinodina venostana*** Buschardt & H. Mayrhofer – On sandstone in a coulee in the Killdeer Badlands. This species was found only once. 1788 (det. Sheard, confirmed H. Mayrhofer). No substances detected by TLC. The specimen is very similar to the type from northern Italy, where all specimens also occur on very fragile substrates, mainly soft schists (H. Mayrhofer, pers. comm. 02 Nov. 2012). The species has also been reported from southwestern Germany.
- \**Sarcogyne hypophaea*** (Nyl.) Arn. (syn. *S. privigna* (Ach.) A. Massal.) – On acidic rock. 2006, 2073.
- Sarcogyne magnussonii* B. de Lesd. – On rock on a grasslands slope in the Two Trees Area. This species was found only once, albeit in abundance on a specific erratic boulder. 829B, 1260 (det. Knudsen and neotypified in Knudsen & Kocourková 2012).
- Sarcogyne regularis* Körber – On calcareous rock. 829B (sub *S. magnussonii*), 983C.
- \**Sarcogyne similis*** H. Magn. – On acidic rock. 818A, 889, 984C, 1785 (det. Knudsen).
- Scytinium tenuissimum* (Dickson) Otálora, P. M. Jørg. & Wedin (syn. *Leptogium tenuissimum* (Dickson) Körber) – On mosses and detritus. 1293, 1307, 1321, 1934 (det. Björk).
- Staurothele areolata* (Ach.) Lettau – On calcareous rock. 550 (sub *Verrucaria bernaicensis*), 553A (sub *Verrucaria othmarii*), 966B, 978B, (det. Breuss).
- Staurothele drummondii* (Tuck.) Tuck. – On calcareous and siliceous rock. 579 (sub *Polysporina urceolata*), 1557, 1684. Both areolate and radiate forms of this species were observed.
- Staurothele elenkinii* Oxner – On soft calcareous rock in Killdeer Badlands. 974.
- \**Staurothele monicae*** (Zahlbr.) Wetmore – On calcareous rock. 1699, 1896.
- Tetramelas papillatus* (Sommerf.) Kalb – On *Selaginella* in the open prairie. 1022B. *Tetramelas papillatus* is normally an arctic-alpine species, which like *Caloplaca tirolensis*, *Ochrolechia upsaliensis*, *Staurothele drummondii* and *S. elenkinii*, for example, is also found in grassland environments (Brodo et al. 2001, Thomson 1997).
- Toninia sedifolia* (Scop.) Timdal – Terricolous on eroded, sloped grassland. 480, 817, 980, 1682.
- Trapeliopsis flexuosa* (Fr.) Coppins & P. James – On dead *Juniperus* and fence posts. 1841, 1909.
- Usnea hirta* (L.) F.H. Wigg. – On exposed, hard wood. 510D.
- Usnea lapponica* Vainio – On *Juniperus* over moss and on *Crataegus* and, as dwarf morphs, on hard lignum. TLC: three chemotypes represented by collections 945 (usnic and salazinic acids), 1810 (usnic acid alone), and 510A (psoromic acid). For distinguishing features and information on the various chemotypes of this species, refer to Halonen et al. (1998, 1999), Törra & Randle (2007).
- \*\**Verrucaria bernaicensis*** Malbr. – On soft calcareous rock on 70 Mile Butte. 550, 553B (sub *V. othmarii*), 1637A (sub *V. muralis*) (det. Breuss).
- \*\**Verrucaria fusca*** Pers. – On acidic rock in the Killdeer Badlands. 1781, 1786 (det. Breuss). Thallus consists of small brown-blackish flecks, mostly closely adjacent to each other and forming an areolate-appearing crust, but individual flecks are discernible in parts of the thallus and at the margin. The flecks are subgelatinous and soft when wetted. Spores are longer than reported for Sonoran specimens. European samples with large spores have been separated as *V. triglavensis* Servít but there seems to be a continuum in measurements (O. Breuss, pers. comm., 01 Oct. 2012).
- Verrucaria glaucovirens* Grumann – On calcareous rock and parasitic on *Staurothele drummondii*. 1628A, 915, 1600C (conf. O. Breuss).
- \*\**Verrucaria inficiens*** Breuss – Parasitic on *Staurothele* when young, independent on acidic and calcareous rocks when mature. 503 (sub *Muellerella erratica*), 910 (sub *Rhizocarpon intermediellum*), 1025, 1683, 1686, 1888 (det. Breuss).
- Verrucaria muralis* Ach. – On calcareous sandstone. 868, 870A, 982, 1637A, 1944 (det. Breuss).

- \*\**Verrucaria othmarii* K. Knudsen & L. Arcadia (syn. *Verrucaria rupicola* (B. de Lesd.) Breuss non (L.) Humb.) – On calcareous rock outcrop on 70 Mile Butte. 553A, 553B (det. Breuss).
- \*\**Verrucaria sphaerospora* Anzi – On calcareous outcrop in Wood Mountain Uplands. 1889.
- Vulpicida pinastri* (Scop.) J.-E. Mattsson & M.J. Lai – On mossy logs in Wood Mountain Uplands. 944, 1338.
- Xanthomendoza fallax* (Hepp ex Arnold) Søchting, Kärnefelt & S.Y. Kondr. – Poorly formed on *Fraxinus*, *Sarcobatus* and *Ulmus*. 584, 987, 1705, 1861 (sub *Phaeophyscia hirsuta*).
- \**Xanthomendoza fulva* (Hoffm.) Søchting, Kärnefelt & S.Y. Kondr. – On *Juniperus* in the Three Sisters Area. This species was found only once and in poor condition. 1596.
- Xanthomendoza montana* (L. Lindblom) Søchting, Kärnefelt & S.Y. Kondr. – On *Artemisia*, *Fraxinus*, *Populus*, *Sarcobatus*, *Ulmus* and wood. 920, 1271, 1622, 1729, 1828, 1917. Collected in the Frenchman River Valley in 1989 and determined as *Xanthoria polycarpa* by G. F. Ledingham, one of the founders of Grasslands National Park. (Lindblom 1997; CANL!).
- \*\**Xanthoparmelia camtschadalis* (Ach.) Hale – Erratic over soil and detritus as well as attached to soil and pebbles in a manner typically ascribed to *X. wyomingica* (Hale 1990). This species was described by Hale (1990) and Rosentreter (1993) as vagrant only, but this does not apply for the species as observed in the Park. 922A, 1001, 1385, 1694, 1776, 1794, 1803, 1949B, 2014.
- Xanthoparmelia chlorochroa* (Tuck.) Hale – Erratic over soil. 555, 925A, 1037, 1374, 1555, 1693, 1765. It is not uncommon to find *X. chlorochroa* growing in and consolidating soil in badlands and on mudflats (Fig. 2-F), whereas typically the species is described as obligatory vagrant (Brodo et al. 2001, Hale 1990, Nash & Elix 2004, Rosentreter 1993). In these same areas, heavy runoffs wash large numbers of thalli against shrubs or rocks where they accumulate and continue to grow attached to soil.
- Xanthoparmelia idahoensis* Hale – Vagrant over soil. Originally reported by Goffinet et al. (2001) from the northwest corner of the West Block; additional specimens were not found during the course of this study.
- Xanthoparmelia lineola* (E.C. Berry) Hale – Tightly attached to acidic rock although often becoming strongly rugose and loosely attached centrally. 777, 781, 923, 1376, 1605. TLC: usnic acid, fatty acid, (possibly constipatic acid), salazinic acid.
- \**Xanthoparmelia loxodes* (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch – On siliceous rock on the North Gillespie Trail. 1804. TLC: glomelliferic, glomellic, perlatolic acids.
- Xanthoparmelia mexicana* (Gyelnik) Hale – On acidic rock and rarely on dead *Juniperus*. 1044, 1352, 1359, 1799, 1839.
- \**Xanthoparmelia subdecepiens* (Vainio) Hale – On smooth quartz stones, on sloped and upland grasslands. 497, 780A, 811, 845, 1000, 1050, 1381. TLC: murolic and neodihydromurolic acids, two of several fatty acids present in this species in proportions depending on geographic location (J.A. Elix, pers. comm., 08 Jan. 2010).
- Xanthoparmelia wyomingica* (Gyelnik) Hale – On soil and partially attached to pebbles and small stones. 506, 1949A. This species also grows over and entangled in *Selaginella*, *Phlox hoodii*, *Cladonia pocillum* and *Physconia muscigena* and is thus a component of the short-grass prairie turf. 1611, 1645, 1763, 1846. TLC: (all) usnic acid, salazinic acid, norstictic acid (trace). Previously, *X. wyomingica* has only been described as loosely adnate to free-growing on pebbles and soil and restricted to exposed habitats in alpine areas in the Rocky Mountains and the Columbia basin (Hale 1990, McCune & Rosentreter 2007, Nash & Elix 2004).
- Xanthoria elegans* (Link.) Th. Fr. – On siliceous and calcareous rock. 521, 818B, 849, 2066.
- Xanthoria* cf. *tibellii* S.Y. Kondr. & Kärnefelt. – On *Artemisia* and *Sarcobatus* twigs. 794, 1681C. This taxon is referable to *Xanthoria tibellii* but differs by having slightly smaller and ellipsoid rather than widely ellipsoid spores. In comparison, *Xanthomendoza montana*, also found on twigs in the same area, has larger, narrowly ellipsoid to cylindrical spores (Lindblom 1997). *Xanthomendoza hasseana* also has narrow, overlapping and vertically separated lobes, but that species has larger spores with a distinctly broader septum (Lindblom 1997). Examination of the holotype for *X. tibellii* (Wetmore, Telosch. Exs. 21 [KRAM-L-44353]) on loan confirmed the presence of a specimen sub *Xanthomendoza montana* that corresponded to the description of the new species. The CANL duplicate, however, includes only *X. montana* (and a small sample of *X. fallax*). Kondratyuk and Kärnefelt (2003) examined but two other specimens in addition to the holotype: one from Ontario and another collected in 1859 by the botanist on John Palliser's British North

American Exploring Expedition in what is now known as Saskatchewan. Unfortunately, these were not available for investigation on loan. Comparison with additional material is required.

## CHECKLIST OF LICHENICOLOUS FUNGI

- \**Arthonia epiphyscia* Nyl. – On *Physcia stellaris* (thallus). 1564, 1904, 1905 (sub *Tremella christiansenii*). This species is known in Canada from Alberta (Diederich 2003), British Columbia (Diederich 2003, Goward et al. 1996), Newfoundland (NY) and Nunavut (Zhurbenko 2009).
- \**Arthonia molendoi* (Heufl. ex Frauenf.) R. Sant. – On *Xanthoria elegans* (apothecia). 822B, 1336, 1761. This species was reported from Canada (British Columbia) by Alstrup & Cole (1998).
- Caloplaca epithallina* Lynge – On *Dimelaena oreina*. 1597, 1642, 1762, 1849.
- \*\**Cercidospora lobothealliae* Nav.-Ros. & Calat. – On *Lobothallia alphoplaca* (thallus). 1885. For the original description of this species, refer to Navarro-Rosinés et al. (2004).
- Cercidospora* sp. 01. – On *Caloplaca trachyphylla* (thallus and apothecia). 1773. Pseudothecia sub-globose, 168 µm in diameter, immersed with ostiole protruding slightly; ascomatal wall pale below, dark above with area around ostiole bright green-blue; asci cylindrical, 75.1–82.6 × 10.7 µm, 8-spored; ascospores hyaline, ellipsoid, 1-septate, heteropolar, narrower and shorter cell straight or occasionally slightly bent, (17.7–)18.3–19.5 × (5.5–)6.1–7.3 µm. Resembles *Cercidospora caudata* as originally described by Kernstock (1895), notably with both ascospore cells being of similar shape; however, Hafellner (1987) and Navarro-Rosinés et al. (2004) describe that species as having ascospore cells of very different in shape and size, with the lower cell curved and attenuated as a tail.
- Cercidospora* sp. 02 – On *Xanthoria elegans* (apothecia). 2086. Pseudothecia sub-globose, black, semi-immersed in host hymenium, 138 µm in diameter; ascomatal wall brown; asci cylindrical, 54.9–61.2 × 13.4–15.3 µm, 4-spored; ascospores hyaline, ellipsoid, 1-septate, heteropolar, 16.5–20.1 × 6.1–7.3 µm.
- \*\**Endococcus oreinae* Hafellner – On *Dimelaena oreina* (thallus). 1643. Hafellner et al. (2002) provided the original description of *Endococcus oreinae*.
- \**Intralichen christiansenii* (D. Hawksw.) D. Hawksw. & M.S. Cole – On *Candelariella vitellina* (apothecia). 1267 (sub *Rinodina juniperina*). This species was reported from Canada (British Columbia) by Alstrup and Cole (1998) and Hawksworth and Cole (2002).
- \*\**Lichenocodium lichenicola* (P. Karst.) Petrak & H. Sydow – On *Physcia stellaris* (apothecia). 1339 (det. Diederich).
- \**Lichenodiplis lecanorae* (Vouaux) Dyko & D. Hawksw. – On *Caloplaca pyracea* and *Lecanora hagenii* (apothecia). 1344B, 1565, 1566, 1588, 1864, 1903 (det. Diederich). This species is known in Canada from Newfoundland (NY), Nova Scotia (CANL), Ontario (Brodo et al. 2013) and Quebec (Diederich 2003).
- \**Lichenostigma cosmopolites* Hafellner & Calatayud – On *Xanthoparmelia wyomingica* (thallus). 2030, 2038, 2041, 2042. Hafellner and Calatayud (1999) provided the original description of this species and reported it in Canada from British Columbia and Ontario.
- Muellerella erratica* (A. Massal.) Hafellner & V. John (syn. *Muellerella pygmaea* var. *athallina* (Müll. Arg.) Triebel) – On *Caloplaca trachyphylla* (thallus) and saxicolous crustose species (cf. *Lecidea*) (apothecia). 503, 1599, 1630, 2035, 2045. The species is known in Canada from British Columbia (CANL), Ontario (Brodo et al. 2013), Newfoundland (NY), New Brunswick (CANL), Northwest Territories (Triebel 1989, Zhurbenko 2013) and Nunavut (Zhurbenko 2009, Zhurbenko & Daniels 2003).
- Phoma caloplacae* D. Hawksw. – On *Caloplaca cerina* and *C. stillicidiorum* (apothecia). 864, 903C, 931d, 1324, 1357 (det. Diederich; cited in Lawrey et al. 2012).
- Phoma xanthomendozae* Diederich & Freebury – On *Xanthomendoza montana* (apothecia). 1616, 1681B (det. Diederich). Lawrey et al. (2012) described this species and reported it from Quebec.
- \**Polycoccum clauzadei* Nav.-Ros. & Cl. Roux – Forming galls on *Xanthoria elegans* (thallus). 1262, 1316, 2088, 2089 (det. Diederich). This species is described in Navarro-Rosinés & Roux (1998) and was reported in Canada (Nunavut) by Diederich (2003).
- \*\**Polysporina pusilla* (Anzi) M. Steiner ex Kantvilas – On saxicolous crustose species. 891B, 975, 1024B, 1552, 1556 (det. Knudsen). Although initially described as a lichen, this species was subsequently recognized as lichenicolous by Knudsen and Kocourková (2008).



- \**Polysporina subfuscescens* (Nyl.) K. Knudsen & Kocourk. – On saxicolous crustose species. 562, 972A, 979A (det. Knudsen).
- \**Sphaerellothecium cladoniae* (Alstrup & Zhurb.) Hafellner – (syn. *Sphaerellothecium araneosum* (Arnold) Zoph var. *cladoniae* Alstrup & Zhurb.) On *Cladonia pocillum* (thallus & apothecia). 994, 2039. This species was reported in Canada from Nunavut (Zhurbenko 2009, Zhurbenko & Alstrup 2004) and the Northwest Territories (Zhurbenko 2013).
- \*\**Stigmidium squamariae* (B. de Lesd.) Cl. Roux & Triebel – On *Lecanora garovaglii* (apothecia). 1023, 1878. Collected once in association with a *Sphaerellothecium* species with brown vegetative hyphae as described by Roux and Triebel (1994). For discussion on the presence of pseudoparaphyses in *S. squamariae* and related taxonomic issues, refer to Roux and Triebel (2005) and Kocourková and Knudsen (2009).
- \**Taeniolella rolfii* Diederich & Zhurb. – Forming galls on the branch tips of *Cetraria aculeata*. 1941, 1027. This species was reported in Canada from the Northwest Territories (Zhurbenko 2013) and Nunavut (Diederich & Zhurbenko 2001).
- \**Tetramelas pulverulentus* (Anzi) A. Nordin & Tibell (syn. *Buellia pulverulenta* (Anzi) Jatta) – On *Physconia muscigena* (thallus). 913A, 1576, 1594, 1606, 1947. This species was reported in Canada from British Columbia (Alstrup & Cole 1998, Goward & Ahti 1992), the Northwest Territories (Thomson & Scotter 1992) and Nunavut (Diederich 2003).
- \*\*\**Tremella christiansenii* Diederich – Forming cerebriform galls on *Physcia stellaris*. 1540, 1562, 1563, 1856, 1905 (det. Diederich). This species was reported for Austria and Denmark (Diederich 1996).
- \**Zwackhiomyces coepulonus* (Norman) Grube & R. Sant. – On *Xanthoria elegans* (thallus). 838, 1368 (det. Diederich). Previously reported in Canada for British Columbia (Goward et al. 1996).

## DISCUSSION

Grasslands National Park provides a lichen refuge within the mixed-grass prairie ecozone, now largely transformed by the widespread introduction of agriculture (Bailey et al. 2010, Forrest et al. 2004, Gauthier et al. 2003, Hammermeister et al. 2001, Kerr & Cihlar 2004, Kerr & Deguise 2004, Shorthouse 2010). Each of eight visits to the Park yielded additional lichen species, and surely there are more to be discovered. For example, twenty of thirty-three species mapped by Brodo et al. (2001) for Southern Saskatchewan have not yet been found in the Park. As well, newly acquired and to-be-acquired lands within the projected boundaries of the Park remain unexplored. Although habitats in these new locations will be similar to those already visited, variations in access to sunlight, exposure to prevailing winds and availability of water can have a significant effect on lichen populations (Buschbom & Kappen 1998, Canters et al. 1991, Hauck et al. 2007) and possibly support new species and interesting varieties.

Conserving lichens within the Park itself is a concern in view of small populations and the restricted amount of suitable habitat (Benedict et al. 1996, Lindenmayer & Fischer 2006). For example, a wildfire such as the one that swept over 51 km<sup>2</sup> of the Park in 2013 destroyed much of the lichen biota on the species-rich grassland slopes in the Two Trees Area. Recovery will at least partly depend on the availability of propagules and algae from a small adjacent area that escaped the fire (Bailey 1976, Eversman & Horton 2004, Johansen et al. 1984), which in turn could rely on how that piece of land is managed. Excessive grazing/trampling is likely to destroy and degrade this potential source of reproductive material (Brotherson et al. 1983, Johansen & St. Clair 1986), whereas insufficient grazing could contribute to more intense fires in the future as the result of the build up of fuel (Stubbendieck et al. 2007). Detailed information on the lichens of this area could be useful in formulating management policies to facilitate the process of post-fire colonization and monitoring their implementation (Rosentreter et al. 2001).

As well as creating an inventory of the lichens of Grasslands National Park, this study also contributes to our knowledge of the lichens of North America, Canada and Saskatchewan. Of the 29 new records for Canada, 23 are lichens and 6 are parasites. In addition, there were 30 new lichen records for Saskatchewan alone, as well as 11 new lichenicolous fungi. The number of new records suggests that the lichens of the Prairie Ecozone of the Northern Great Plains are deserving of much more study.

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**APPENDIX A – KEY TO SPECIES OF *HETEROPLACIDIUM* AND *VERRUCARIA* FROM  
GRASSLANDS NATIONAL PARK  
(based on Breuss 2007)**

- 1a. Parasitic on other lichens, becoming independent .....2
- 1b. Independent .....5
- 2a. Thallus whitish grey, pruinose .....*Verrucaria inficiens*
- 2b. Thallus brown .....3
- 3a. Spores ellipsoid, 17–20 × 8–10 µm .....*Verrucaria glaucovirens*
- 3a. Spores broadly ellipsoid to sub-globose .....4
- 4a. Spores 13–16 × 8–10 µm, perithecia reaching below algal layer ..... *Heteroplacidium compactum*
- 4b. Spores 10–13 × 8–10 µm, perithecia entirely within algal layer .....*Heteroplacidium zamenhofianum*
- 5a. Thallus usually endolithic, indistinct or only around perithecia .....*Verrucaria muralis*
- 5b. Thallus distinctly epilithic .....6
- 6a. Thallus of dispersed, subgelatinous, blackish granules; involucrellum reaching down to base of perithecium .....*Verrucaria fusca*
- 6b. Thallus areolate, not subgelatinous .....7
- 7a. Perithecia on areole margins; involucrellum enveloping exciple; spores sub-globose to globose .....  
..... *Verrucaria sphaerospora*
- 7b. Perithecia immersed within areoles .....8
- 8a. Thallus grey or whitish grey .....9
- 8b. Thallus brown .....10
- 9a. Thallus roughly pruinose; initially parasitic, then independent .....*Verrucaria inficiens*
- 9b. Thallus epruinose, lichenized only .....*Verrucaria bernaicensis*
- 10a. Spores ellipsoid .....11
- 10b. Spores broadly ellipsoid to sub-globose .....12
- 11a. Areoles subdivided into small units, making surface uneven; spores 17–20 × 8–10 µm .....  
.....*Verrucaria glaucovirens*
- 11b. Areoles cracked areolate to subsquamulose, spores 12–15 × 5–7 µm ..... *Verrucaria othmarii*
- 12a. Perithecia reaching below algal layer, spores 13–16 × 8–10 µm ..... *Heteroplacidium compactum*
- 12b. Perithecia entirely within algal layer; spores 10–12 × 9–10 µm .....*Heteroplacidium zamenhofianum*

# A review of the genus *Bulbothrix* Hale: the isidiate, lacinulate, sorediate and pustulate species with medullary gyrophoric, lecanoric and lobaric acids, together with a world key for the genus

MICHEL N. BENATTI<sup>1</sup>

**ABSTRACT.** – This study is a taxonomic review of the species of *Bulbothrix* (Parmeliaceae, lichenized fungi) containing gyrophoric, lecanoric or lobaric acid in the medulla (*Bulbothrix apophysata*, *B. funicola*, *B. laevigatula*, *B. leprieurii*, *B. oliveirae*, *B. papyrina*, *B. pseudofungicola*, *B. pseudocoronata*, *B. scortela*, *B. sipmanii*, *B. subdissecta* and *B. thomasiana*) that reproduce by lichenized diaspores (isidia, lacinulae, pustules, or soredia). Some of these species (*B. bulbillosa*, *B. papyrina*, *B. pseudocoronata*, *B. pseudofungicola*, *B. scortella*, *B. subdissecta*, and *B. thomasiana*) have been separately treated on previous papers as novelties, new combinations or resurrected valid names. The current species delimitations are confirmed. New characters are detailed (for *B. laevigatula*, *B. leprieurii*, *B. oliveirae*, and *B. sipmanii*), and range extensions are given (for *B. apophysata*, *B. fungicola*, *B. laevigatula*, and *B. leprieurii*). Two names (*B. suffixa* and *Parmelia appressa*) are respectively considered as a *nomen dubium* and *nomen illegitimum* and the problems relative to them are also discussed. A key covering all 59 accepted species of *Bulbothrix* is provided. A lectotype is designated for *B. fungicola*. An index for all names related to the genus, with their current statuses, is also given.

**KEYWORD.** – bulbate cilia, *Hypotrachyna*, Parmeliaceae.

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## INTRODUCTION

*Bulbothrix* Hale was proposed for a group of species that had previously been referred to *Parmelia* series *Bicornutae* (Lyngby) Hale & Kurok. (Hale 1974). The group was characterized by small, lacinate and usually adnate thalli, simple to branched bulbate marginal cilia, cortical atranorin, simple to branched rhizinae, smooth to coronate apothecia, hyaline unicellular ellipsoid to bicornute ascospores  $5.0\text{--}21.0 \times 4.0\text{--}12.0 \mu\text{m}$  in size, and bacilliform to bifusiform conidia  $5.0\text{--}10.0 \times 0.5\text{--}1.0 \mu\text{m}$  in size (Hale 1976, Elix 1993). In a recent paper presenting revised generic concepts of parmelioid lichens based on molecular, morphological and chemical evidence, Crespo et al. (2010) found that *Bulbothrix* as currently defined was nested in the *Parmelina* clade and that some species grouped with *Parmelinella* Elix & Hale, making the genus *Bulbothrix* paraphyletic.

As part of my revision of *Bulbothrix* (Benatti 2010), type specimens and additional material of many species were studied. All of the members of the genus have cilia with hollow basal bulbs, which contain differentiated (round) cells and a characteristic oily substance (Hale 1975, Feuerer & Marth 1997, Benatti 2011a). The first part of my revision concerned new combinations for four species that had been placed in *Bulbothrix* but had to be excluded due to the lack of true bulbate cilia (Benatti & Marcelli 2010). The subsequent parts treated the species containing norstictic and protocetraric acids in the medulla (Benatti 2012b), those with salazinic acid that do not form isidia, soredia, lacinulae or pustulae (Benatti 2012d), those with salazinic acid that form isidia, soredia or pustulae (Benatti 2013a), those with fatty acids or no

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substances in the medulla (Benatti 2013b), and those containing gyrophoric/lecanoric/lobaric acids that do not reproduce by vegetative propagules (Benatti 2013c).

This paper reviews for the first time four species with gyrophoric acid (*Bulbothrix fungicola*, *B. lepriurii*, *B. oliveirae*, *B. sipmanii*), one with lecanoric acid (*B. laevigatula*), and one with lobaric acid (*B. apophysata*), that form isidia, lacinulae, soredia or pustulae. The remaining species reviewed here (*B. bulbillose*, *B. papyrina*, *B. pseudocoronata*, *B. pseudofungicola*, *B. scortella*, *B. subdissecta*, *B. thomasiana*) were all treated in other recent publications but are included for completeness due to their medullary chemistries and production of lichenized diaspores (Marcelli et al 2011, Benatti 2011a-b, 2012a-d, 2013a-c).

In order to complete my revision of the genus and clarify the concepts of species, the type specimens of all *Bulbothrix* names and many additional specimens from several herbaria worldwide were studied. After having revised all of the species of *Bulbothrix* in groups according their reproductive mode and chemistry (Benatti 2011a-b, 2012a-d, 2013a-c, Benatti & Marcelli 2010, Benatti & Elix 2012, Bungartz et al. 2013 and herein) I compiled a key to the genus, which is also presented here. This key is based on the considerable amount of new data obtained from type and additional specimens, as well as from recent publications that were not directly part of my revision (Benatti 2011a-b, 2012a-d, 2013a-c, Benatti & Elix 2012, Benatti & Marcelli 2010, Marcelli et al. 2011, Bungartz et al. 2013). It is hoped that this key, which synthesizes the available literature and my research to date, will facilitate the identification of *Bulbothrix* specimens and stimulate further study. Also, an index with all the names related to *Bulbothrix*, including the basionyms and current accepted names, is given for historical reference.

## MATERIALS AND METHODS

For the taxonomic review presented below, type material and additional specimens were borrowed from the following herbaria: B, BM, DUKE, FH, G, H, LD, M, MSC, NY, PC, S, SP, TNS, U, US UPS, and W. This material originated from Asia, Africa, North America, Central America, the Caribbean and South America. Also included in the studied material were the Brazilian collections made during the last 30 years, mainly by the author and the members of the Lichenological Study Group of the Instituto de Botânica (GEL) in Brazil.

The methods and terminology follow those detailed in Benatti (2012a). The following terms that may be unfamiliar to readers are also used: “sublacinulate” follows Marcelli et al. (2008) and Spielmann and Marcelli (2009) to describe that there are not true lacinulae as intended as a secondary outgrowth similar to the main ramifications, but rather occasional poorly developed small outgrowths. Bulbs on cilia, rhizines, apothecia and other thallus parts were examined using the clarification method outlined by Benatti (2011a). Chemical constituents of the additional specimens examined were identified by thin-layer chromatography (TLC) using solvent C (Bungartz 2001), and compared with the data on labels included with the specimens. The chemical constituents of the type specimens were examined by high performance liquid chromatography (HPLC) by J.A. Elix, following the methods described in Elix et al. (2003).

Gyrophoric and lecanoric acids have similar spot test reactions for the C and KC tests, but it was found that at least in *Bulbothrix*, the color reactions for the two substances are noticeably distinct, especially when comparing specimens side by side. Those containing gyrophoric acid usually react C+ and KC+ rose (with a weakly white bluish brightness under UV depending on concentrations), while those containing lecanoric have a stronger red reaction without any apparent signs of UV brightness. Microcrystal tests (G.E. and G.A.W.) were also used to confirm which of these two substances was present in the specimens studied, as the crystals are very different in shape and size. Lobaric acid was detected by a C- and KC+ violet rose reaction and a typical white bluish brightness under UV light.

The key appended to the treatment below consists of data obtained from the study of type material and additional specimens from B, BM, C, CANB, DUKE, FH, FI, G, GLAM, H, HMAS, HUFSCAr, L, LD, LG, LWG, M, MEL, MSC, NY, PC, S, SP, TNS, TUR, U, US, UPS, VEM, W, WU, and from the personal herbarium of Dr. Klaus Kalb (hb. Kalb, now transferred to WIS). This material was collected in Oceania, Asia, Africa, North America, Central America, Caribbean and South America. The methods and terminology used follow those detailed in the published treatments of each group of species in the literature cited.



## RESULTS

### I: REVIEW OF THE SPECIES

Examination of the specimens outlined in the materials and methods section above confirmed the existence of twelve *Bulbothrix* species containing gyrophoric, lecanoric or lobaric acids that develop vegetative propagules. Below, all species not already treated elsewhere in recent contributions by me are described in detail and their diagnostic characters are discussed. In many cases new morphological data are presented and the secondary metabolites present are clarified. Based on this study *B. apophysata*, *B. fungicola*, *B. laevigatula*, *B. leprieurii*, *B. oliveirae*, *B. papyrina*, *B. pseudofungicola*, *B. pseudocoronata*, *B. scortella*, *B. sipmanii*, *B. subdissecta* and *B. thomasiana* are recognized. All of these are considered to be corticolous species, since so far none has been found to be saxicolous.

#### SPECIES NOT TREATED IN PREVIOUS CONTRIBUTIONS

*Bulbothrix apophysata* (Hale & Kurok.) Hale, Phytologia 28(5): 480. 1974.  
Mycobank #341589.

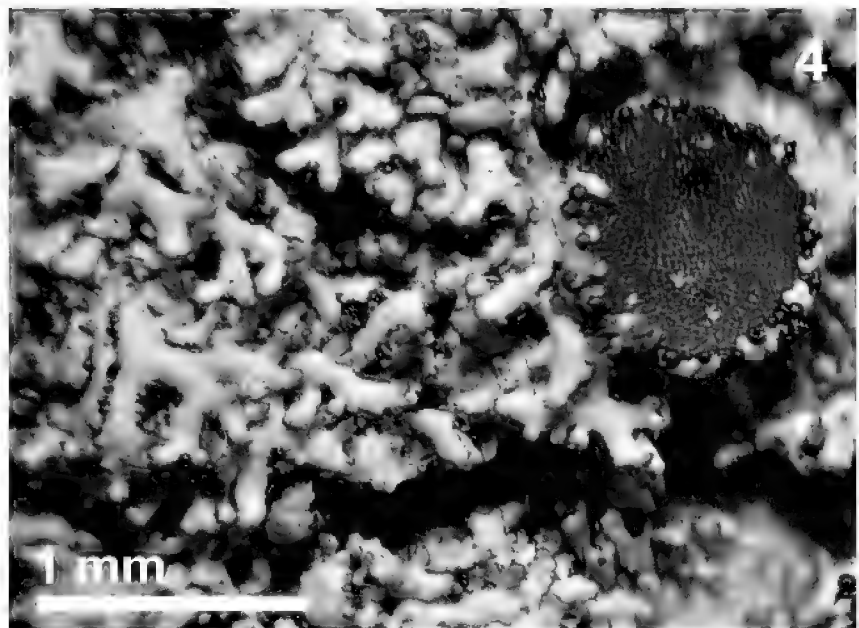
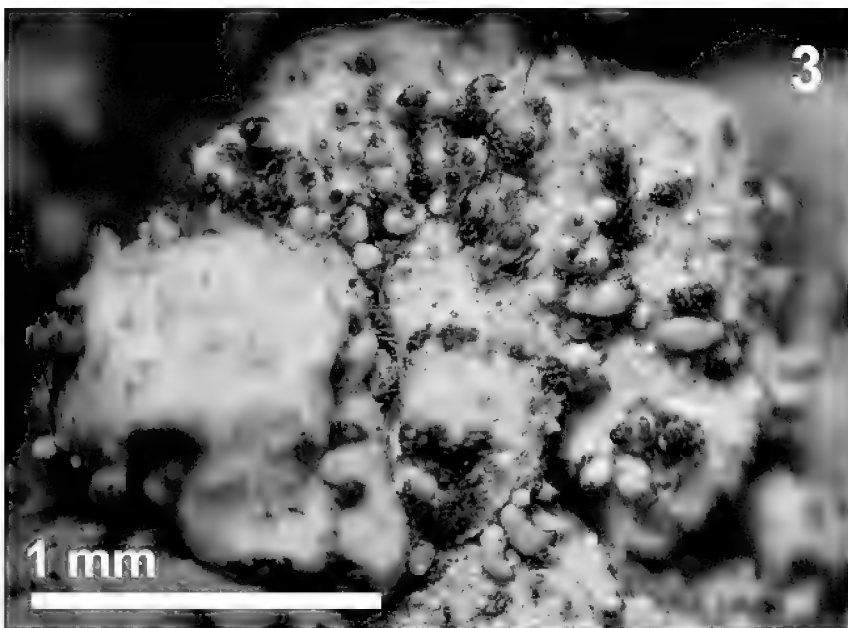
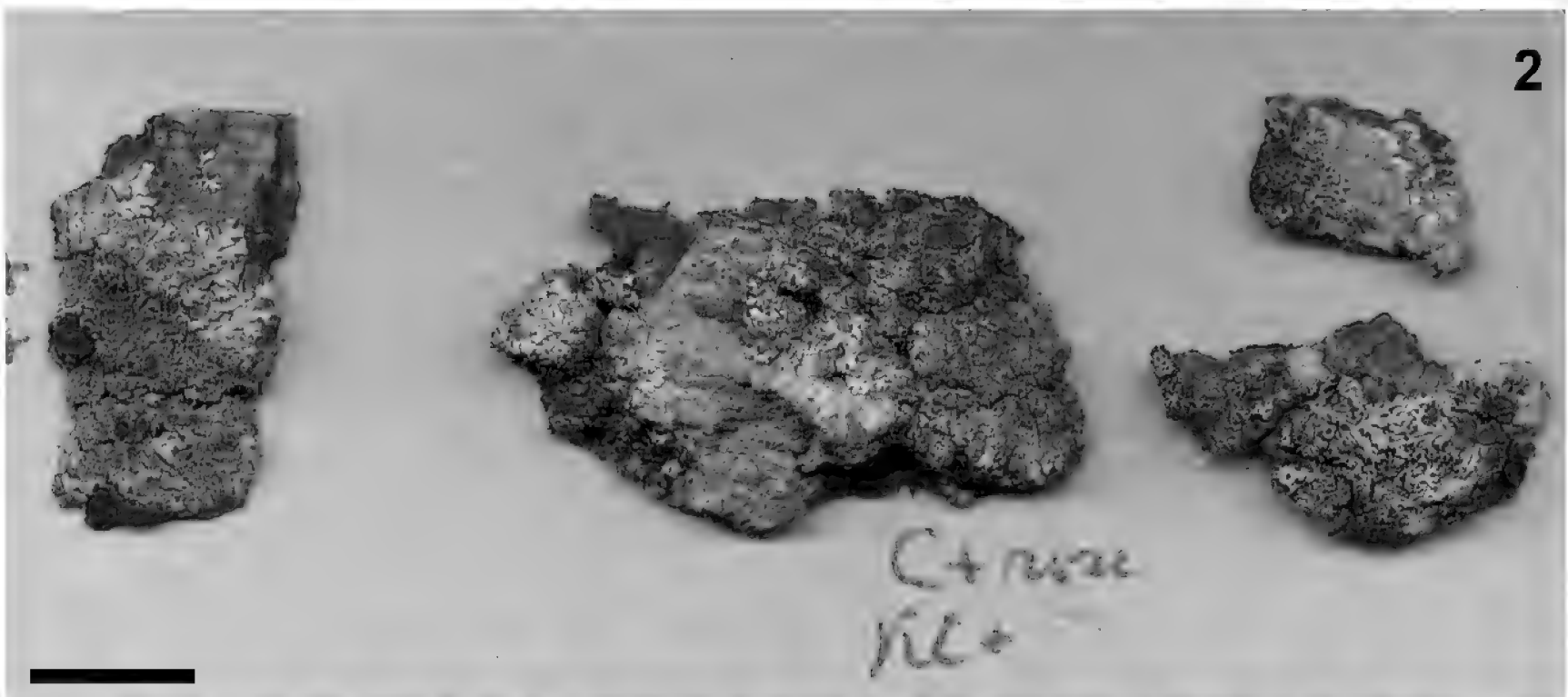
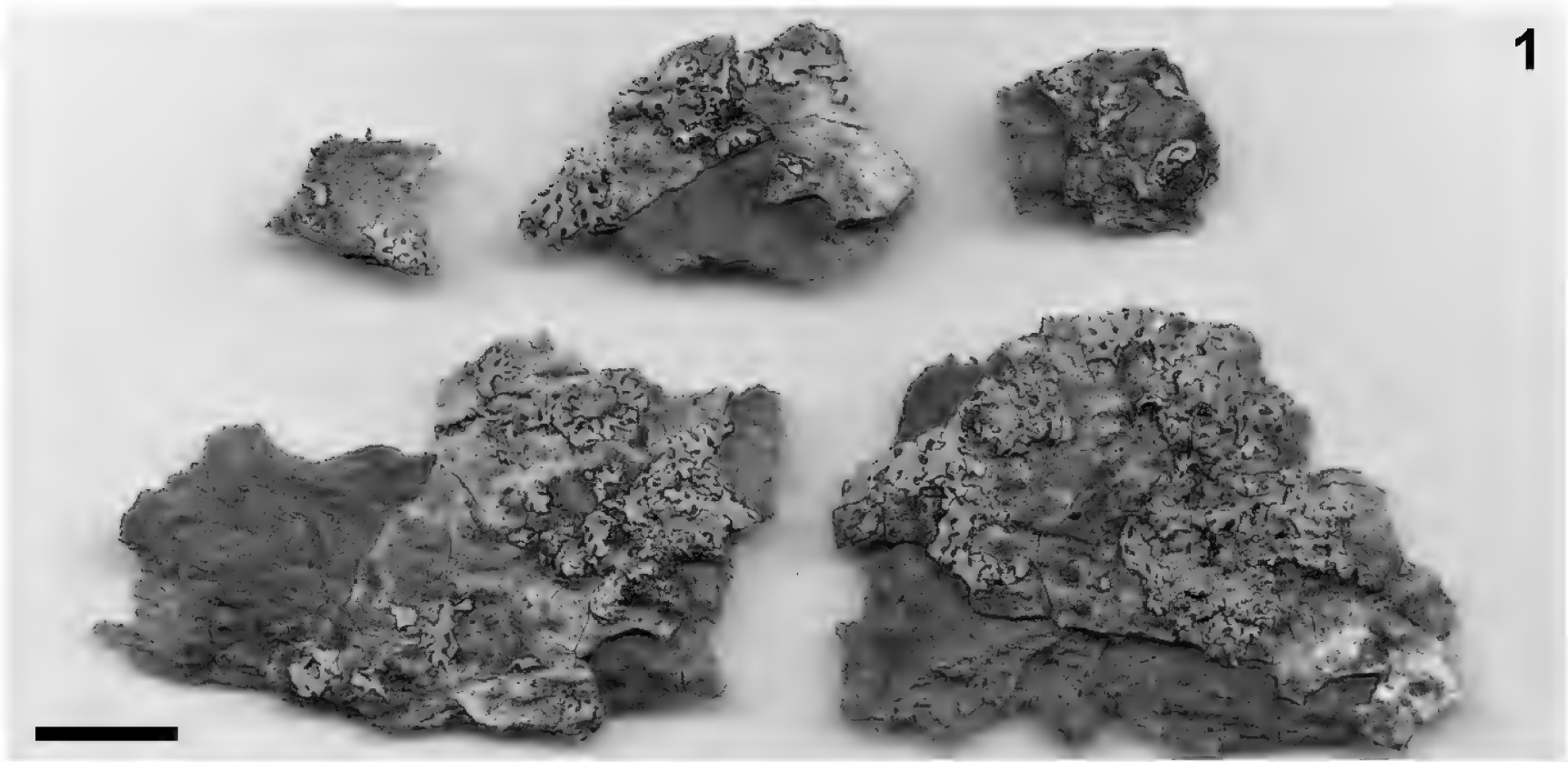
≡ *Parmelia apophysata* Hale & Kurok. Contrib. U. S. Natl. Herb. 36: 138. 1964. **TYPE:**  
**DOMINICAN REPUBLIC: LA VEGA:** vicinity of Piedra Blanca, in pine barrens, alt. 200-500 m., on mangrove tree, 14.x.1947, *H. A. Allard 16073*, (US!, holotype; TNS!, isotype).

#### FIGURE 1.

**DESCRIPTION.** – Thallus sublinear, laciniate, pale dusky gray in herbarium, up to 5.3 cm diam., subcoriaceous, corticolous, upper cortex 20.0–35.0  $\mu\text{m}$  thick, algal layer 20.5–30.0  $\mu\text{m}$  thick, medulla 37.5–55.0  $\mu\text{m}$  thick, lower cortex 10.0–15.0  $\mu\text{m}$  thick. Lacinae anisotomic to irregularly dichotomously branched, 0.4–1.6 mm wide, contiguous to imbricate, adnate and appressed, with flat, truncate to subtruncate apices, margins plane, smooth and sinuous to irregular, entire, scarcely sublacinulate, axils oval. Upper surface smooth, slightly to densely irregularly cracked (especially at older parts), laminal ciliary bulbs absent. Adventitious marginal lacinulae scarce on random parts, short, 0.2–0.7  $\times$  0.1–0.2 mm, plane, simple to irregularly branched, apices truncate, lower side concolorous with the lower marginal zone. Maculae weak and scarce, punctiform, laminal but restricted to a few parts, usually amidst the scars left by fallen isidia. Cilia black to occasionally brown, apices initially simple, furcate or trifurcate, soon becoming dichotomously or irregularly branched, 0.05–0.25 (–0.35)  $\times$  ca. 0.03 mm, with semi-immersed sessile bulbate bases ca. 0.05–0.10 mm wide, abundant throughout the margin spaced 0.05–0.10 mm from each other to contiguous at the axils, absent at the apices of the lacinae. Soredia, and pustulae absent. Isidia frequent, laminal, granular to smooth cylindrical, straight to tortuous, 0.05–0.25  $\times$  ca. 0.05 (–0.10) mm, simple to rarely slightly branched, erect, persistent to  $\pm$ caducous, concolorous with the cortex or with pale brownish apices, eciliate. Medulla white. Lower surface black with brown to dark brown parts at the transition from the margins, shiny, smooth, papillate, densely rhizinate. Marginal zone pale brown to brown, occasionally slowly attenuate gradually darkening to black in the center, the paler part ca. 0.5–2.5 mm wide, shiny, smooth, papillate, becoming rhizinate towards the center. Rhizinae black, brown or whitish, initially simple or furcate becoming dichotomously or irregularly branched, bulbs typically basal but also sometimes displaced further along the length, 0.05–0.30 (–0.40)  $\times$  ca. 0.03 mm, usually frequent but less common at the marginal zone, evenly distributed. Apothecia and pycnidia not found.

**CHEMISTRY.** – Atranorin, lobaric acid (TLC/HPLC). Spot tests: upper cortex: K+ yellow; medulla K–, C–, KC+ violet rose, P–, UV+ bluish white to pale blue.

When Hale and Kurokawa (1964) described this species they did not identify the KC+ substance in the medulla, although they thought it may be related to alectoronic acid. The identity of the substance as lobaric acid was later determined by Hale (1976).



**Figures 1-4.** 1, holotype of *Bulbothrix apophysata* (US). 2, type collection of *B. fungicola* (S); the lectotype is composed of the three fragments from center to right; the leftmost fragment belongs to *B. pseudocoronata*. 3, detail of one of the fragments of *B. fungicola* showing isidia. 4, detail of the leftmost fragment belonging to *B. pseudocoronata*, showing typical laminal lacinulae and a coronate apothecia. Scale bars = 1 cm, except where noted.

DISTRIBUTION. – Oceania: Australia (Elix 1994). Central America and Caribbean Sea: Panama, Dominican Republic, Trinidad & Tobago (Hale 1976), Costa Rica (Tenorio et al. 2004). South America: Venezuela (López-Figueiras 1986, Marcano et al. 1996) and Brazil (Brako et al. 1985, Fleig & Grüniger 2000, Marcelli 1993). Here this species it is reported for the first time from Peru.

NOTES ON THE TYPE SPECIMENS. – The holotype (fig. 1) of *Bulbothrix apophysata* is a very fragmented specimen, consisting of small, partially moldy pieces 1.0–2.5 cm in diameter, without apothecia or pycnidia. The isotype also consist of fragments 1.0–3.0 cm in diameter that are not moldy and are better preserved, although also without any apothecia or pycnidia.

COMMENTS. – The material examined corresponds well to the descriptions of Hale and Kurokawa (1964) and Hale (1976), especially regarding the width of the laciniae, the cracks and weak maculae of the upper cortex, the branching pattern of the cilia and rhizines and the size and shape of the isidia. The authors did not mention ciliate isidia, such as those described by Marcelli (1993). In fact, no isidia in the material I studied, even the most developed ones, showed any sign of the formation of cilia.

Hale and Kurokawa (1964) and Hale (1976) described a peculiarity related to the color contrast between the center and the margins on the lower surface of this species. The presence of a centrally black lower surface starkly contrasting with a broad pale brown marginal zone is a most notable feature in the specimens. This feature is variable however, with some laciniae superficially appearing to have a variable brown lower surface until close examination reveals a black area in the central portions.

Hale and Kurokawa (1964) compared *Parmelia apophysata* (= *Bulbothrix apophysata*) only to *P. subdissecta* (= *B. subdissecta* (Nyl.) Hale), which was later placed in synonymy with *B. goebelii* (Zenker) Hale by Hale (1976). Study of the type of *B. goebelii* revealed that the name actually should be applied to a non-isidiate taxon that could be considered the parental species of *B. apophysata* (Benatti & Elix 2012). Thus *B. subdissecta*, proved to be a distinct taxon that differs by its somewhat narrower laciniae (ca. 0.5–1.0 mm wide), predominantly black lower cortex with subtly attenuated brown margins, and medullary gyrophoric acid often with small amounts of lobaric acid (Benatti & Elix 2012).

The specimens cited by Marcelli (1993) as *Bulbothrix apophysata* have a pale brown lower cortex and mostly ciliate isidia, with small cilia bearing branched apices. This material was recently described as *B. thomasi* Benatti & Marcelli (Marcelli et al. 2011). *Bulbothrix thomasi* is indeed similar to *B. apophysata*, but differs by the presence of ciliate isidia, cilia that are often branched at the apices and by the overall pale brown lower surface which is usually hidden by concolorous or somewhat darker rhizines.

**Additional specimen examined.** – **PERU: SAN MARTÍN:** Tingo María, near Huallaga River near Tingo María, 625–1100 m, on tall vine, 30.viii.1949–19.ii.1950, *H. A. Allard* 22256 (US).

***Bulbothrix fungicola* (Lynge) Hale**, Phytologia 28(5): 480. 1974.  
Mycobank #341598.

≡ *Parmelia fungicola* Lynge. Arkiv för Botanik 13(13): 129. 1914. **TYPE: BRAZIL:** “civit. Matto Grosso, Santa Anna da Chapada”, in “cerrado”, 27.ii.1894, *G.O. Malme* 2438B (S!, **lectotype here designated**).

#### FIGURES 2, 3 AND 4.

DESCRIPTION. – Thallus sublinear laciniate, dusky gray in herbarium, fragments up to 2.7 cm diam., subcoriaceous, corticolous (often ramulicolous), upper cortex 17.5–20.0 µm thick, algal layer 15.0–25.0 µm thick, medulla 35.0–55.0 µm thick, lower cortex 15.0–20.0 µm thick. Laciniae isotomic to anisotomic dichotomously or trichotomously to occasionally irregularly branched, 0.2–0.7 (– very rarely 1.2) mm wide, contiguous to slightly imbricate, very adnate and strongly appressed, with flat, truncate to subtruncate or occasionally acute apices, the margins plane, smooth to sinuous or subirregular, entire to slightly incised, scarcely sublacinulate, the axils oval and narrow. Upper surface smooth and continuous, becoming subrugose at older parts, laminal ciliary bulbs absent (ciliary bulbs that superficially appear to be laminal can be seen sometimes due to the initial growth of isidia and apothecia). Adventitious marginal lacinulae scarce and randomly arranged, short, 0.2–0.5 × 0.1–0.2 mm, plane, simple to rarely furcate, truncate or acute, lower side concolorous with the lower marginal zone. Maculae distinct, punctiform to efigurate,

laminal, amidst the scars left by fallen isidia. Cilia black, apices absent to simple or occasionally furcate, frequently bent downwards,  $0.05\text{--}0.10$  ( $-0.15$ )  $\times$  ca.  $0.03$  mm, with semi-immersed bulbate bases ca.  $0.05$  ( $-0.10$ ) mm wide, abundant along the margins spaced ca.  $0.05$  ( $-0.10$ ) mm from each other to contiguous, becoming absent at the apices of the laciniae. Soredia and pustulae absent. Isidia frequent to abundant, laminal, granular to irregularly bent cylindrical, occasionally globose, straight to slightly tortuous,  $0.05\text{--}0.20 \times$  ca.  $0.05$  mm, simple to rarely weakly branched, erect, persistent to caducous, concolorous with the cortex or with brownish apices, usually ciliate with tiny ciliary bulbs without apices or with very short apices. Medulla white. Lower surface black, shiny, smooth to subrugose, densely rhizinate. Marginal zone pale brown and in a narrow band ca.  $0.5$  mm wide, shiny, smooth, slightly papillate and slightly rhizinate. Rhizinae black, partially dark brown or rarely whitish, simple to partially furcate or rarely irregularly branched, without basal bulbs,  $0.05\text{--}0.20$  ( $-0.40$ )  $\times$  ca.  $0.03$  mm, abundant sometimes almost as a tomentum, partially agglutinated, evenly distributed. Apothecia concave to plane, adnate to sessile,  $0.3\text{--}1.8$  mm diam., laminal, margin smooth eventually becoming crenate and almost lobulate due to incisions, coronate, amphithecia smooth or occasionally ornamented with scarce ciliary bulbs, also rarely becoming slightly isidiate. Disc pale to dark castaneous brown, epruinose, imperforate, epithecium  $10.0\text{--}15.0$   $\mu\text{m}$  high, hymenium  $37.5\text{--}55.0$   $\mu\text{m}$  high, subhymenium  $15.0\text{--}22.5$   $\mu\text{m}$  high. Ascospores subglobose to ellipsoid, occasionally with  $\pm$ acute apices and with an almost fusiform aspect,  $(6.5\text{--}) 8.0\text{--}10.0 \times 4.5\text{--}6.0$   $\mu\text{m}$ , epispore  $1.0\text{--}1.5$   $\mu\text{m}$ . Pycnidia scarce, laminal to submarginal, immersed, with black ostioles. Conidia bacilliform to weakly bifusiform  $5.0\text{--}8.0$  ( $-10.0$ )  $\times 0.5$   $\mu\text{m}$ .

CHEMISTRY. – Atranorin, gyrophoric acid (TLC/HPLC). Spot tests: upper cortex: K+ yellow; medulla: K–, C+ and KC+ rose to reddish rose, P–, UV–.

DISTRIBUTION. – Central America and Caribbean Sea: Costa Rica (Tenorio et al. 2004), Dominica, Dominican Republic (Hale 1971). South America: Guyana, Venezuela (Feüerer 2008, López-Figueiras 1986, Marcano et al. 1996) and Brazil (Brako et al. 1985, Fleig & Riquelme 1991, Jungbluth 2006, Lynge 1914, Marcelli 1993). This species is here reported for the first time from Honduras.

NOTES ON THE TYPE SPECIMENS. – The type collection of *Bulbothrix fungicola* (fig. 2) consists of four fragments of tree bark, all in good condition, that are glued to a card backing. Despite their morphological and chemical similarity, one of the fragments lacks laminal isidia and actually belongs to a densely lacinulate species (fig. 4). The admixture of solely laminal lacinulae and solely isidiate fragments (fig. 3) was the probable cause of the confusion by both Lynge (1914) and Hale (1976) that *B. fungicola* was a species that formed both isidia and laminal lacinulae. The lacinulate fragments belong to *Parmelia pseudocoronata* Gyeln. (= *B. pseudocoronata* (Gyeln.) Benatti & Marcelli) (see Benatti 2012c), which was accepted as a synonym of *B. fungicola* by Hale (1976), even though the type material of that name is lacinulate and not isidiate.

COMMENTS. – Lynge (1914) apparently noticed the bulbate marginal cilia in this species but thought that they were a parasitic fungus ("*fungo parasitico instructus*"). He also misinterpreted the medullary reactions, citing them as K + yellow and C– while they are, as Hale (1960) reported, C+ rose and KC+ reddish rose. Hale (1960) also initially believed that "parasitic fungi on the underside were a conspicuous feature" of this species, misinterpreting the cilia or rhizines in the same manner as Lynge. It was only later that he recognized the bulbate cilia were not parasitic fungi (Hale & Kurokawa 1964, Hale 1976).

Marcelli (1993) commented that in cerrado (savannah) environments thalli of *Bulbothrix fungicola* and *B. suffixa* were often found growing together or mixed, and mentioned an unusual feature of *B. fungicola* cited by Hale (1976), the fact that both isidia and lacinulae were present in the same species. Evidently both Lynge (1914) and Hale (1976) believed that the isidia present in *B. fungicola* developed into lacinulae. As has been discussed in the preceding section, the type of *B. fungicola* consists mostly of isidiate material, with a single admixed fragment of a lacinulate thallus that is *B. pseudocoronata*. This admixture is almost certainly what led to the misinterpretation of the vegetative propagules in *B. fungicola* by previous authors, and also may have led Hale (1976) to consider *B. pseudocoronata* to be a synonym of *B. fungicola*. *Bulbothrix pseudocoronata* differs from *B. fungicola* mainly by the formation of laminal and marginal lacinulae that at the very beginning of their development, resemble isidia, but soon afterward start



to flatten to form lacinulae. The laminal isidia produced by *B. fungicola* typically do not resemble the lacinulae of *B. pseudocoronata*. In the rare cases where confusion may occur, the lacinulae found in *B. pseudocoronata* are typically longer, wider, more abundant, more branched, and firmer than the isidia found on thalli of *B. fungicola*. Furthermore, *B. pseudocoronata* has no maculae on the upper surface, the rhizines are less frequent, and the rhizines have bulbate bases.

The material referred by Hale (1971) to *Bulbothrix fungicola* was described as having lobulate isidia, and possibly could be *B. pseudocoronata*. Another curiosity about this material is that it was described as having bicornute ascospores, which would make these isidiate/lobulate specimens similar to *B. semilunata* (Lynge) Hale rather than to *B. fungicola* which does not have bicornuate ascospores. It is also possible that these specimens could be either *B. caribensis* Marcelli & Benatti (lacinulate without medullary substances) or *B. lyngei* Benatti & Marcelli (isidiate with small amounts of fatty acids, also no reactions) (Benatti 2011b).

Specimens of *Bulbothrix fungicola* have narrow laciniae, very rarely exceeding 1 mm wide. The size of the laciniae (0.5–1.5 mm wide) given by Hale (1976) is larger than what was observed in the lectotype and additional material. These were closer to the size cited by Lynge (1914; 0.5–1.0 mm wide). The sizes mentioned by Marcelli (1993) and Jungbluth (2006) best corresponded to those observed here (0.2–0.7 mm wide). *Bulbothrix fungicola* presents only adventitious laminal lacinulae, which are occasional, sparse and random, as poorly developed structures without any apparent function of propagation.

Hale (1976) mentioned simple rhizines for *Bulbothrix fungicola*, while Marcelli (1993) and Jungbluth (2006) reported dichotomously branched rhizines. In the material studied, including the type, simple rhizines dominate among a smaller number of furcate rhizines. *Bulbothrix pseudofungicola* Benatti & Marcelli is similar to *B. fungicola*, but differs by having dichotomously branched cilia and rhizines, coronate apothecia, and usually smaller, mostly subglobose ascospores (Benatti 2012a).

The ascospore sizes for *Bulbothrix fungicola* given by Lynge (1914) and Hale (1976) are similar to those found here. The occasional formation of apiculate ascospores that was mentioned by Lynge (1914) was also observed here. These ascospores are sometimes slightly narrower than the ellipsoid ones, and it is difficult to ascertain if they could somehow be related to the bicornute ascospores of other species in the genus, such as *B. semilunata*. Only a small portion of the ascospores observed in *B. fungicola* have this apiculate aspect and these are mixed among asci with typical ellipsoid ascospores.

*Bulbothrix subdissecta* is also similar to *B. fungicola* but has larger eciliate isidia (about twice the size of those of *B. fungicola*), dichotomously branched cilia and rhizines, ecoronate apothecia and usually additionally contains medullary lobaric acid together with the gyrophoric acid (Benatti & Elix 2012).

*Bulbothrix suffixa* (Stirt.) Hale is a name of uncertain application with a complicated relationship to *B. fungicola*. The issues surrounding the application of *B. suffixa* are discussed under that name at the end of the taxonomic section herein.

*Additional specimens examined.* – **DOMINICAN REPUBLIC: INDEPENDENCIA:** Sierra de Bauruco, ca. 9.5 km S of Puerto Escondito, ca. 18° 18'N, 71° 31'S, 1085 m, in pine forest, on trunk of *Sabal umbraculifera*, 24.i.1987, R.C. Harris 20381 (NY), R.C. Harris 20394 (NY). **HONDURAS: COMAYAGUA:** vicinity of Comayagua, ca. 600 m, 12-23.iii.1947, on dead bark, P.C. Standley & J.P. Chacón s.n. (US). **BRAZIL: MATO GROSSO:** Chapada dos Guimarães, BR-163 Highway, km 37 of the Coxim-Rondonópolis section, next to Itiquira River, 500 m alt., cerrado (savannah), on trunk, vii.1980, M.P. Marcelli 8449 (SP). **SÃO PAULO:** Mogi-Guaçu Municipality, Fazenda Campininha, Estação Biológica de Mogi-Guaçu, dry illuminated cerrado (dense savannah), 7.xii.1976, M. P. Marcelli 15810 (SP), on tree trunk, 19.xii.2002, M.P. Marcelli & P. Jungbluth 35535 (SP); São Manuel Municipality, Fazenda Palmeira da Serra, unofficial private reserve of cerrado (savannah), 3.vi.2003, on tree trunk in the wood, M.P. Marcelli & S.B. Barbosa 35702 (SP); Itirapina Municipality, cerrado (savannah) fragment belonging to the João Batista de Arruda Penitentiary, 22° 13'S, 47° 54'W, 700–800 m alt., on tree trunk, 16.viii.2003, P. Jungbluth et al. 535 (SP); Estação Experimental de Itirapina (Instituto Florestal), Pedregulho, sun exposed area, on tree trunk, 24.iii.2004, P. Jungbluth et al. 823 (SP).

*Bulbothrix laevigatula* (Nyl.) Hale, Phytologia 28(5): 480. 1974.  
Mycobank #341604.

≡ *Parmelia laevigatula* Nyl., Flora 68: 614. 1885. **TYPE: FRENCH GUIANA:** Cayenne, *F.M.R. Leprieur* 504 (H-NYL 35653!), lectotype (selected by Hale 1976); PC!, isolectotype).

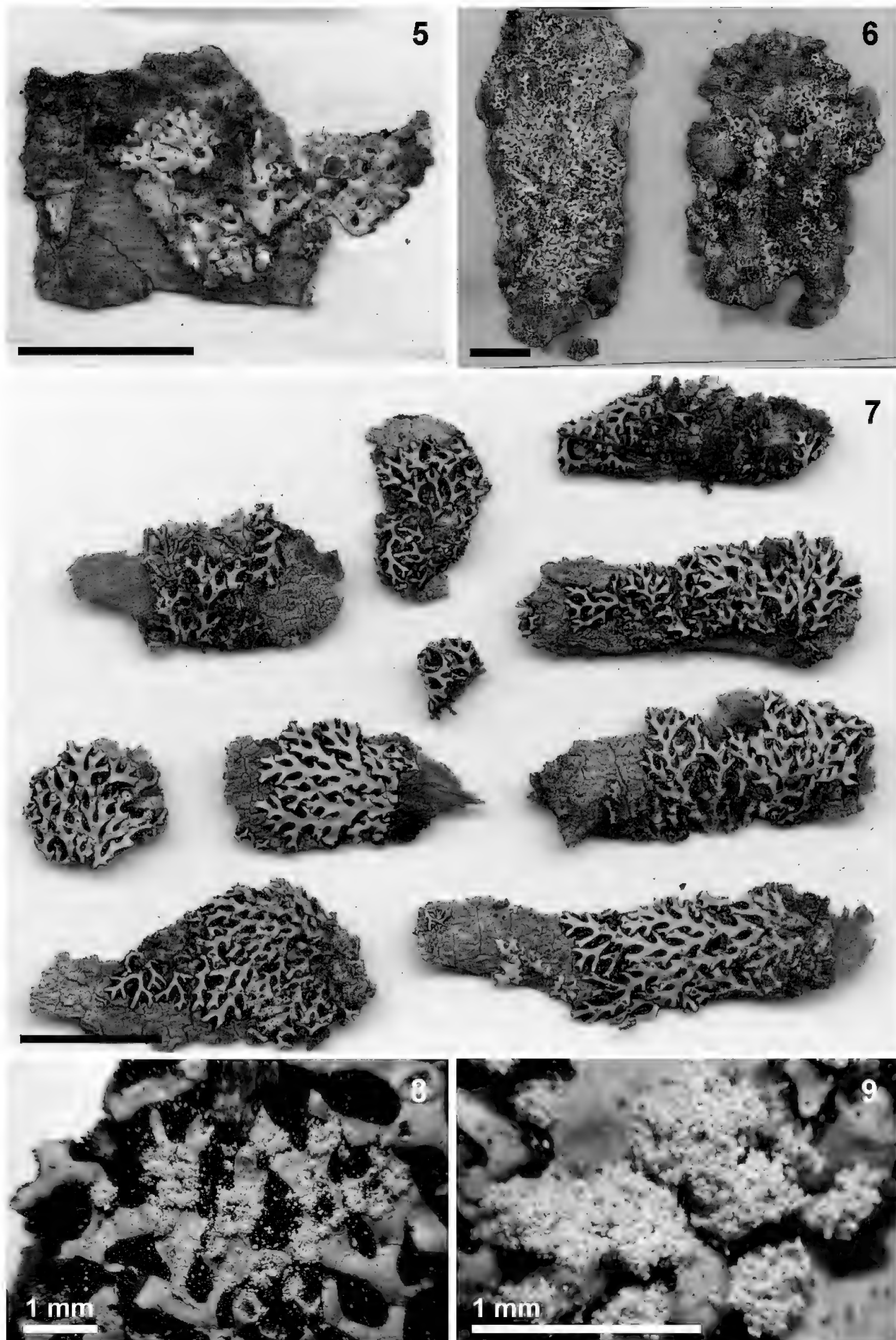
= *Parmelia hookeri* Taylor, London J. Bot. 6: 169. 1847 [non *P. hookeri* (Borrer) Spreng.]. **TYPE: SAINT VINCENT:** without locality, *L. Guilding s.n.* (FH-TAYLOR! lectotype (selected by Hale 1976); BM!, isolectotype).

#### FIGURES 5 AND 6.

**DESCRIPTION.** – Thallus sublinear to partially linear sublaciniate, pale dusky gray in herbarium, up to 6.3 cm diam., subcoriaceous to coriaceous, corticolous, upper cortex 10.0–15.0  $\mu\text{m}$  thick, algal layer 20.0–25.0  $\mu\text{m}$  thick, medulla 50.0–70.0  $\mu\text{m}$  thick, lower cortex 12.5–20.0  $\mu\text{m}$  thick. Laciniae isotomic to anisotomic dichotomously or trichotomously branched, 0.4–2.1 mm wide, contiguous to slightly imbricate, adnate and adpressed, with flat, subtruncate to truncate apices, the margins plane, smooth to sinuous or subcrenate, entire, rarely sublacinulate, the axils oval. Upper cortex continuous and smooth occasionally becoming irregularly cracked on older parts, laminal ciliary bulbs absent. Adventitious lacinulae absent to few scarce on random parts at the margins, short, 0.2–1.1  $\times$  0.1–0.3 (–0.8) mm, plane, simple to rarely furcate, apices truncate, lower side concolorous with the lower marginal zone. Maculae absent, only with some scars left by fallen isidia. Cilia black or rarely pale, apices initially simple, soon becoming furcate, trifurcate and then subdichotomously or irregularly branched, 0.05–0.30 (–0.40)  $\times$  ca. 0.03 mm, with semi-immersed to sessile bulbate bases 0.05–0.15 mm wide, abundant along the margins, spaced ca. 0.05 mm from each other to contiguous at some parts or at the axils, usually absent at the apices of the laciniae. Soredia and pustulae absent. Isidia frequent, laminal, often sparse to grouped, granular to smooth cylindrical, straight to slightly tortuous, 0.05–0.25 (–0.40)  $\times$  ca. 0.05 mm, simple, erect to procumbent, persistent to caducous, brownish or concolorous with the upper cortex, sometimes with brownish apices, eciliate, variably (few to most) losing the apical portion. Medulla white. Lower surface black, shiny, smooth to subrugose, moderate to densely rhizinate. Marginal zone black and indistinct from the central portions to brown in a narrow band 0.5–1.5 mm wide, shiny, smooth, papillate, becoming rhizinate at the transition to the center. Rhizinae black, often brown when near the margins, initially simple or furcate soon becoming dichotomously or irregularly branched, without bulbate bases (a few seen appear to have very subtle ones), 0.05–0.30 (–0.50)  $\times$  ca. 0.03 mm, frequent to abundant almost like a tomentum being scarcer next to the margins, evenly distributed. Apothecia subconvex to  $\pm$ plane or concave, sessile to adnate or substipitate, 0.2–2.9 mm diam., laminal or submarginal, margin smooth to subcrenate, ecoronate, amphithecia smooth eventually becoming isidiate. Disc brown to dark brown, epruinose, imperforate, epithecium 5.0–7.5  $\mu\text{m}$  high, hymenium 25.0–37.5  $\mu\text{m}$  high, subhymenium 12.5–15.0  $\mu\text{m}$  high. Ascospores subglobose to ellipsoid or ovoid, 6.0–8.0 (very rarely –11.5)  $\times$  4.0–5.0 (–6.0)  $\mu\text{m}$ , epispore ca. 0.5 (–1.0)  $\mu\text{m}$ . Pycnidia scarce, laminal, immersed, with black ostioles. Conidia bacilliform to weakly bifusiform, 5.0–7.5  $\times$  0.75  $\mu\text{m}$ .

**CHEMISTRY.** – Atranorin, lecanoric acid (TLC/HPLC); upper cortex K+ yellow, medulla K–, C+ bright red, KC+ bright red→pale orange, P–, UV–.

**DISTRIBUTION.** – Asia: Japan (Nylander 1890), Philippines (Vainio 1909 sub *Parmelia hookeri*) and Thailand (Wolseley et al. 2002 sub *P. hookeri*). Africa: Angola (Vainio 1901 sub *P. hookeri*). North America: Mexico (Hale 1976) and United States of America (Hale 1976, McCullough 1964, Moore 1968). Central America and Caribbean Sea: Costa Rica (Nájera et al. 2002, Tenório et al. 2004 as the synonym *P. hookeri*), Cuba, Dominica, Dominican Republic, Granada, Jamaica, Saint Lucy, Trinidad and Tobago (Hale 1976), Saint Vincent (Taylor 1847 sub *P. hookeri*). South America: Colombia, Ecuador, Peru, Venezuela (Hale 1976) and Brazil (?, Nylander 1885 [see comments below], Hale 1976; Marcelli 1987, 1991, 1993). The species is reported here for the first time from Honduras and Puerto Rico, and to the Brazilian states of Amazonas and Pará.



**Figures 5-9.** 5, lectotype of *Bulbothrix laevigatula* (H-Nyl). 6, lectotype of *Parmelia hookeri* (FH). 7-9, holotype of *B. leprieuri* (U) showing overall appearance of specimen (7), soralia eroding on a fragment (8) and detail of a soralia with soredia (9). Scale bars = 1 cm, except where noted.



NOTES ON THE TYPE SPECIMENS. – The lectotype of *Bulbothrix laevigatula* (fig. 5) is a small thallus fragment in good condition, on tree bark and glued to a card. It has only two apothecia and few intact isidia. Apparently this was part of a larger collection identified as “LePrieur 504” that was distributed to various herbaria, as duplicates were also found in H-NYL and in PC.

Regarding these duplicates, two specimens in H-NYL belong to different species, but the specimen cited by Hale (1976) and labeled by him as the lectotype is indeed *Bulbothrix laevigatula*. The other specimen in H-NYL has ciliate isidia, a pale brown lower cortex, medullary lobaric acid, and was identified as *B. thomasi* Benatti & Marcelli (Marcelli et al. 2011). The duplicate in PC is an isidiate fragment containing lecanoric acid and probably is *B. laevigatula*, but is in poor condition, very damaged and dusky brownish. Because Hale (1976) did not mention ciliate isidia, and described the lower surface as black, I believe that he did not carefully examine other specimens such as those cited here.

There are two specimens at FH representing type material of *Parmelia hookeri*. As discussed by Hale (1958), one of them (“collection 1”) has gyrophoric acid and branched cilia, while the other (“collection 2”) has lecanoric acid. Hale (1976) selected “collection 2” as the lectotype (fig. 6 herein) and this specimen clearly is conspecific with *Bulbothrix laevigatula*. The lectotype comprises two fragments on bark, both glued to a backing, but in excellent condition. I removed a fragment from the substrate for observation of the characteristics of the lower cortex. The specimen referred to as “collection 1” was identified only to genus (i.e., *Parmelia* sp.) and considered to be related to *P. chiliana* Nyl. by Hale (1958). Following Hale (1971) *P. chiliana* is likely a synonym of *P. scortella*. Nonetheless my examination of “collection 1” revealed it to be a species of *Parmelinopsis*, likely *P. minarum* (Vain.) Elix & Hale.

The isoelectotype of *Parmelia hookeri* in BM was annotated by Hale as the “lectotype”. This material is not a fragment, but an entire well developed thallus in good condition. A label from Bruno Mies noted the presence of lecanoric acid in the material, and there is another label proposing a combination of this epithet into *Parmelina*. Evidently the latter combination was never published. The material has bulbate cilia and is *B. laevigatula*. At some point Hale must have decided to select a specimen in FH-TAYLOR as the lectotype rather than the well developed specimen in BM.

The type material and additional specimens examined of *Bulbothrix laevigatula* and *Parmelia hookeri* lack ciliate isidia, and have ecoronate apothecia. No specimen found, even those already identified with these names, showed variation in these characteristics.

COMMENTS. – Nylander (1885) described the ascospores of *Bulbothrix laevigatula* as “7.0–8.0 × 4.0–5.0 µm”, and on a label with the lectotype drew ellipsoid ascospores marking them with similar measurements (“8.0 × 5.0 µm”). The specimens seen here generally have ascospores of this size range, except for a single specimen of the Brazilian State of Amazonas, which has occasional ascospores up to 11.5 µm in length, which is unusual for the species.

The descriptions of Hale (1976) and Marcelli (1993) match well the material studied here, however those authors mentioned slightly smaller ascospores than were found here. The description by Hale (1976) did not include data on the chemistry of the species. Marcelli (1993) described thalli with a very pale yellowish lower marginal zone and black rhizines, with occasional subtle bulbate bases. One specimen cited by Marcelli that I examined has ciliate isidia and a pale lower cortex, lobaric acid, and it is in fact a small specimen of *B. thomasi*. According to Nylander (1885) the lectotype had acicular acuminate conidia, 6.0–7.0 × 0.5–0.6 µm in size. After careful examination of the specimen no pycnidia with conidia were found.

As seen in several specimens, including the type material of *Parmelia hookeri*, it is common that some of the isidia have severed apices, thus resembling pseudocyphellae. This feature varies from few to almost all isidia on some thalli (few specimens lack this feature). This may represent a stage of development in the isidia or be due to environmental factors (Bungartz et al. 2013).

*Bulbothrix goebelii* was compared to *B. laevigatula* by Hale (1976) and Marcelli (1993). Although many authors had applied the name to *B. goebelii* to an isidiate species, Benatti and Elix (2012) recently showed that the type was a mixture and the name should be applied to a species without propagules and containing medullary lobaric acid. The concept of *B. goebelii* followed by Hale (1976) best corresponds to *B. subdissecta*. That species has a black lower surface with black rhizines, a brown lower marginal zone and contains gyrophoric acid as the main substance often associated with small quantities of lobaric acid. The concept of *B. goebelii* followed by Marcelli (1993) corresponds to *B. scortella*, another species which has a brown lower surface, brown rhizines and gyrophoric acid as the main substance (Benatti & Elix 2012). In direct comparison of the thalli, cilia and rhizine branching in *B. goebelii*, *B. scortella* and *B.*



*subdissecta* are more prominently dichotomously branched than in *B. laevigatula*. Moore (1968) compared *B. scortella* to *B. laevigatula*, separating it from *B. laevigatula* by the brown lower surface and presence of gyrophoric acid instead of lecanoric acid.

Hale (1976) considered *Bulbothrix laevigatula* possibly to be the isidiate counterpart of *B. confoederata* (W.L. Culb.) Hale. *Bulbothrix confoederata* differs by the absence of isidia, usually having narrower laciniae (ca. 0.5–1.0 mm wide), and a lower surface with mixed patches of black and brown (most often brown). *Bulbothrix bicornuta* (Müll. Arg.) Hale is another species with lecanoric acid, it differs from *B. laevigatula* in lacking isidia and having apothecia with much larger, bicornute ascospores ( $13.0\text{--}21.0 \times 3.0\text{--}4.0 \mu\text{m}$ ).

*Bulbothrix apophysata* is also similar to *B. laevigatula* and differs almost exclusively by the presence of lobaric acid instead of lecanoric acid. The lower surface of *B. apophysata* also often has a much more indistinct transition from the pale marginal zone to darker center compared with *B. laevigatula* and other members of the genus. This feature was also noted by Hale (1976).

Vainio (1909) mentioned a single specimen he identified as *Parmelia hookeri*, citing a K+ yellow→red (salazinic or norstictic acid?) and a C– medulla. Although the material supporting this concept is currently missing, it is clearly not conspecific with *B. laevigatula*.

*Additional specimens examined* – **UNITED STATES OF AMERICA. FLORIDA:** FRANKLIN CO.: just beyond Eastpoint, dense scrub oak forest, iv.1963, *M. E. Hale* 21695 (US). **MISSISSIPPI:** MARION CO.: Red Bluff near Morgantown, open mixed woods, growing on bark of trees, 17.i.1970, *K.E. Rogers* 2673 (US). **NORTH CAROLINA.** CARTERET CO.: Harker's Island, vicinity of bridge from mainland, maritime forest, on bark of *Pinus*, 6.vi.1973, *T.L. Esslinger* 4030 (DUKE). **CUBA:** Sevilla estate, near Santiago, on *Clusia*, 29.viii.1906, *N. Taylor* 74a (NY). **DOMINICAN REPUBLIC:** **BARAHONA:** above Monteada Nueva, 17 km N of Cabral, then 24 km E to “El Gajo”, humid broadleaf forest, 4200–4300 ft., 4.v.1982, *R.C. Harris* 15264 (NY). **PUERTO RICO:** Bosque Estatal de Guajataca, Vereda La Caballa, ca. 18° 25'N, 66° 58'W, ca. 225 m, mesic forest over limestone, 11.i.1992, *R.C. Harris* 27446 (NY). **TRINIDAD:** north post to Maqueripe, on bark of tree, 22.iii.1920, *E.G. Britton et al. s.n.* (NY). **COSTA RICA: CARTAGO:** on the road Limón-Turrialba, ± halfway between Siquirres and Chitaria, fence poles between pasture and road, ca. 700 m alt., 9.i.1979, *H. Sipman* 12371p.p. (NY). **HONDURAS: MORAZÁN:** San Juan del Rancho, north of Cerro de Uyuca, alt. ~1500 m, pine-oak forest region, xi-xii.1948, *P.C. Standley s.n.* (NY). **VENEZUELA: AMAZONAS:** Depto Rio Negro, Cerro de la Neblina massif., Camp 7, ca. 1850 m, open ridge top *Bonnetia* forest with an understory dominated by large tank bromeliads and with large granitic outcrops, 29.xi-3.xii.1984, *L. Brako* 7693 (NY), *L. Brako* 7878 (NY). **BRAZIL: AMAZONAS:** Pico Rondon, Bald Spur vicinity, clusetum along stream, 3.ii.1984, *G.J. Samuels et al. 109* (NY). **BAHIA:** Am fluß Buranhém, gegenüber der Stadt Porto Seguro, na dünnen Ästchen Am Rand einer Mangrove, 2 m, 23.vii.1980, *K. Kalb & M.P. Marcelli s.n.* (M). **MATO GROSSO:** Buriti, Reserva Biológica do Colégio Evangélico de Buriti, 600–650 m alt., hillside forest more or less clear with some trees cerrado (savannah), 7.vii.1980, *M.P. Marcelli* 7908 (SP). **PARÁ:** Serra do Cachimbo, approx. 10 km N of the Base Aérea do Cachimbo, along the Cuiabá-Santarém highway (BR163) ca. 9°22'N, 54°54'W, ca. 430–480 m, campina, 28.iv.1983, *L. Brako & M. Dibben* 6285 (NY). **RIO DE JANEIRO:** 3.5 km ENE of city of Mangaratiba, at the beach “Praia do Saí”, at NW corner of Sepitiba Bay (where the beach meets the mountain that forms the point “Ponta do Saí”, opposite the small island “Ilha do Saí”), at sea level, 22° 57'S, 44° 01'-2'W, 1–2 m up on trunk of small live tree at back of beach, 17.iv.1966, *G. Eiten & L.T. Eiten* 7079 (US).

*Bulbothrix leprieurii* Aubel, Mycotaxon 44(1): 2. 1992.

Mycobank #358463.

**TYPE: GUYANA:** Upper Mazaruni District, small white sand-savannah ca. 2 km S of Waramadan, ca. 600 m, 5° 47'N, 60° 46'W, epiphyte on isolated, dwarfed tree, 1.iii.1985, *H.J.M. Sipman & A. Aptroot* 19187 (U!, holotype).

## FIGURES 7, 8 AND 9.

**DESCRIPTION.** – Thallus linear to sublinear laciniate, pale greenish gray in herbarium, fragments up to 3.2 cm diam., submembranaceous, corticolous, upper cortex 12.5–17.5  $\mu\text{m}$  thick, algal layer 15.0–20.0  $\mu\text{m}$

thick, medulla 55.0–72.5  $\mu\text{m}$  thick, lower cortex 12.5–15.0  $\mu\text{m}$  thick. Laciniae anisotomic dichotomously to occasionally irregularly branched, 0.3–0.7 mm wide, contiguous, adnate and appressed, with flat, truncate to subtruncate apices or partially acute, the margins plane, smooth and sinuous to irregular, entire, scarcely sublacinulate, the axils oval or irregular. Upper cortex mostly continuous and smooth, but often with many transverse cracks on older or densely sorediate parts, laminal ciliary bulbs absent. Adventitious marginal lacinulae scarce on older parts, short, flat,  $0.20\text{--}0.50 \times 0.05\text{--}0.30$  mm, simple or irregularly branched, truncate or acute, underside concolorous with the lower marginal zone. Maculae absent. Cilia black, apices initially simple, soon becoming furcate and then very dichotomously branched,  $0.05\text{--}0.25 \times$  ca.  $0.02\text{--}0.03$  mm, with semi-immersed to sessile bulbate bases ca.  $0.05\text{--}0.10$  mm wide, abundant along the margins and generally contiguous, being scarce only on the apices of the laciniae. Soralia subcapitate, hemispheric to subplane, laminal or subapical, looking somewhat like pustulae at the very beginning of their development, forming small bumps that open soon. Soredia subgranular,  $30.0\text{--}75.0$   $\mu\text{m}$  diam. True pustulae absent, the soralia initially opening from below the upper cortex forcing an opening, and when emptied looking like burst, totally eroded pustulae, leaving the lower cortex exposed or with a few medullary hyphae visible. Isidia absent. Medulla white. Lower surface black, shiny, smooth to subrugose, moderate to densely rhizinate, with some naked parts. Marginal zone brown, attenuate  $0.2\text{--}0.5$  mm wide, occasionally black and indistinct from the center, shiny, smooth, becoming rhizinate at the transition to the center. Rhizines black, initially furcate soon becoming very dichotomously branched, partially with basal bulbs or enlarged bases,  $0.10\text{--}0.20$  ( $\text{--}0.30$ )  $\times$  ca.  $0.03$  mm, frequent to abundant being sparse in some parts, evenly distributed. Apothecia subplane to concave, sessile to adnate,  $0.4\text{--}2.2$  mm diam., laminal, margin and amphithecium smooth, coronate, eventually sorediate. Disc brown, epruinose, imperforate, epithecium  $5.0\text{--}10.0$   $\mu\text{m}$  high, hymenium  $25.0\text{--}35.0$   $\mu\text{m}$  high, subhymenium  $15.0\text{--}20.0$   $\mu\text{m}$  high. Ascospores rounded to ellipsoid,  $(5.0\text{--}) 6.0\text{--}8.0 \times 4.0\text{--}6.0$   $\mu\text{m}$ , epispore ca.  $1.0$   $\mu\text{m}$ . Pycnidia scarce, laminal, immersed, with black ostioles. Conidia bacilliform to weakly bifusiform  $5.0\text{--}7.0 \times 0.75$   $\mu\text{m}$ .

CHEMISTRY. – Atranorin, gyrophoric acid, variable small quantities of lecanoric and orselinic acids also present according to Sipman and Aubel (1992) (TLC/HPLC); upper cortex K+ yellow, medulla K–, C+ and KC+ rose to reddish rose, UV–.

The presence of lecanoric and orselinic acids was not confirmed here and they could be contaminants as originally suspected by the authors at the time of description. Two labels with the holotype, one from Aptroot and another from Sipman, mention only the presence of gyrophoric acid.

DISTRIBUTION. – South America. Colombia and Guyana. Here reported for the first time from Brazil (States of Amazonas, Mato Grosso, Pará, and São Paulo).

NOTES ON THE TYPE SPECIMEN. – The holotype (fig. 7) consists of several fragments, all in good condition.

COMMENTS. – Currently, there are only two known sorediate species of *Bulbothrix* (*B. imshaugii* (Hale) Hale and *B. leprieurii*), and two known pustulate species (*B. pustulata* (Hale) Hale and *B. oliveirae*). The descriptions of *B. oliveirae* and *B. leprieurii* called attention to the fact that both appeared to form similar soredia, and that eventually the sorediate pustulae or soralia became excavate exposing the lower cortex. The morphological similarities between the two species and the presence of the same chemical medullary substance (gyrophoric acid), raised the suspicion that they could perhaps represent different stages related to the formation and release of soredia of the same species. However, after study it is clear that they can be distinguished by differences in the development of the vegetative propagules.

As described by Sipman and Aubel (1992), the soralia of *Bulbothrix leprieurii* vary from capitate to partially plane and excavate (fig. 8). As is noted in the description, I have examined thalli with more hemispherical soralia (fig. 9) and others with plane soralia. At a certain stage, the soralia in all specimens eventually erode and release the soredia, finally becoming excavate and exposing the lower cortex. This ontogeny can be observed in several fragments on the holotype of *B. leprieurii*.

The bumps or “calluses” that form at the initiation of soraliium development cannot always be observed on a given specimen, but typically can be found sparsely on the surface of younger portions of the thallus. If these are examined in section with a transverse cut, it is possible to observe soredia in the immature soraliium. Thus these structures are very different from the empty space present in a hollow

pustule. In the later stages of development, when the lower cortex is exposed, the holes left by the emptied soralia give a very similar appearance to that of pustules that have erupted and fragmented as can be observed in *Bulbothrix oliveirae*.

Because the soralia of *B. lepriurii* and the pustules of *B. oliveirae* appear almost identical at the final stages of development, the greatest difficulty in distinguishing the species occurs when all or most of these structures have eroded. Under these conditions there are few differences left, except the narrower laciniae in *B. lepriurii* (0.3–0.7 mm vs. 0.5–1.5 mm wide in *B. oliveirae*), that are also more linear and frequently sublacinulate, a more continuous (less cracked) upper cortex, and rhizines that are less abundant in *B. lepriurii* when compared to *B. oliveirae*.

The differences between *Bulbothrix lepriurii* and *B. oliveirae* can be subtle and difficult to interpret without prior experience. This is evidenced by the fact that all of the specimens cited in the protologue of *B. oliveirae*, except for the holotype, actually represent typical sorediate specimens of *B. lepriurii*.

As was mentioned above the only other sorediate species of *Bulbothrix* known is *B. imshaugii*. That species differs from *B. lepriurii* by having wider laciniae with rounded apices (ca. 1.5–4.5 mm wide), a maculate upper cortex, simple cilia and rhizines, and by the presence of salazinic acid rather than gyrophoric acid in the medulla. *Bulbothrix coronata* (Fée) Hale is also similar in having dichotomously branched cilia and rhizines, coronate apothecia and medullary gyrophoric acid. But it differs from *B. lepriurii* in having wider laciniae (ca. 0.5–1.0 mm wide) and by not forming soralia or any kind of lichenized propagule.

*Additional specimens examined* – **BRAZIL: AMAZONAS:** between Manaus and São Gabriel, along Rio Negro at Temendui Lagoon, campina, ca. 00° 35'S, 64° 40'W, on branch, 30.vi.1979, *W.R. Buck* 2242 (NY). **MATO GROSSO:** 842 km N of Cuiabá on Cuiabá-Santarém highway (BR-163), ca. 8° 45'S, 54° 57'W, ca. 350–500 m, mature forest along stream on sandy soil with deep humus and roadbank vegetation, on roadside Solanaceae, 5.v.1983, *L. Brako & M. Dibben* 6716 (NY), *L. Brako & M. Dibben* 6727 (NY). **PARÁ:** Serra do Cachimbo, Base Aérea do Cachimbo, ca. 20 km N of the border with Mato Grosso on Cuiabá-Santarém highway (BR-163), ca. 9° 22'S, 54° 54'W, ca. 430–480m, broad, sandy level plain along Rio Braço de Norte with sandstone exposures, low ridges and valleys to the N & S, 26.iv.1983, *L. Brako & M. Dibben* 6012 (NY). **SÃO PAULO:** Ilha Comprida Municipality, Vila das Pedrinhas, at the southern part of the island, clearing in the restinga woods in a place being allotted, 3 m alt., on small tree trunk, 26.ix.2006, *M. N. Benatti & M. J. Kitaura* 2226 (SP), *M. N. Benatti & M. J. Kitaura* 2227 (SP); side of the road near the ferry to the Island of Cananéia, on tree trunk at the edge of restinga wood, 3.iv.2004, *L.S. Canêz et al.* 1229 (SP), on thin tree branch inside the restinga wood, *L. S. Canêz et al.* 1276 (SP).

*Bulbothrix oliveirae* **Fletcher in Hale**, (as “*oliverai*”), *Mycotaxon* 25(1): 86. 1986.  
Mycobank #104077.

**TYPE: BRAZIL: PARÁ:** Serra do Cachimbo, Base Aérea do Cachimbo, ca. 20 km N of the border with Mato Grosso on Cuiabá-Santarém highway (BR-163), ca. 9° 22'S, 54° 54'W, ca. 430–480m, broad, sandy level plain along Rio Braço de Norte with sandstone exposure, low ridges and valleys to the N & S, 23.iv.1983, *L. Brako & M. J. Dibben* 5804[c] (NY!, holotype).

#### FIGURES 10 AND 11.

**DESCRIPTION.** – Thallus sublinear laciniate, greenish gray in herbarium, fragments up to 3.7 cm diam., submembranaceous, corticolous, upper cortex 12.5–17.5 µm thick, algal layer 15.0–20.0 µm thick, medulla 60.0–75.0 µm thick, lower cortex 12.5–15.0 µm thick. Laciniae anisotomic dichotomously to irregularly branched, (0.3)–0.5–1.2 mm wide, contiguous becoming partially crowded at the center, adnate and appressed, with flat, truncate to subtruncate apices, the margins plane, smooth to sinuous or irregular, entire to slightly incised, commonly sublacinulate mainly at older parts, the axils oval to partially irregular. Upper cortex smooth and continuous, with few occasional transversal or irregular fissures, laminal ciliary bulbs absent. Adventitious marginal lacinulae scarce to abundant, especially on older parts, short, 0.2–0.8 × 0.1–0.3 mm, plane, simple to furcate or rarely irregularly branched, apices truncate, lower side concolorous with the lower marginal zone. Maculae absent. Cilia black, apices initially simple, soon becoming furcate and finally dichotomously branched, 0.05–0.25 × ca. 0.03 mm, with semi-immersed to sessile bulbate bases ca. 0.05–0.10 mm wide, abundant along the margins, spaced up to 0.05 mm from each other to contiguous,

becoming scarce at the apices of the laciniae. Pustulae in the form of rounded to irregular bumps or blisters, laminal to commonly apical or subapical on the laciniae and lacinulae, their walls eroding from the middle out sometimes forming corticate, coarse granules, leaving a small portion of medullary hyphae with the lower cortex or exposing it totally. Soredia-like grains scarce, subgranular and coarse, partially corticate, originating from the fragmentation of the walls and external rim of the pustulae and not true soralia. Isidia absent. Medulla white. Lower cortex black, shiny, smooth to subrugose, densely rhizinate with some random open areas. Marginal zone black and indistinct from the center to a dark brown and very narrow band ca. 0.1–0.2 mm wide, shiny, smooth, becoming rhizinate at the transition to the center. Rhizinae black to rarely pale brown, initially furcate commonly becoming very dichotomously branched, partially with bulbate bases,  $0.10\text{--}0.30 \times \text{ca. } 0.03$  mm, abundant almost like a tomentum, sometimes however being less frequent at random areas, evenly distributed. Apothecia and pycnidia not found.

CHEMISTRY. – Atranorin, gyrophoric acid (TLC/HPLC); upper cortex K+ yellow, medulla K–, C+ and KC+ rose, UV–.

DISTRIBUTION. – South America: Brazil (Hale 1986).

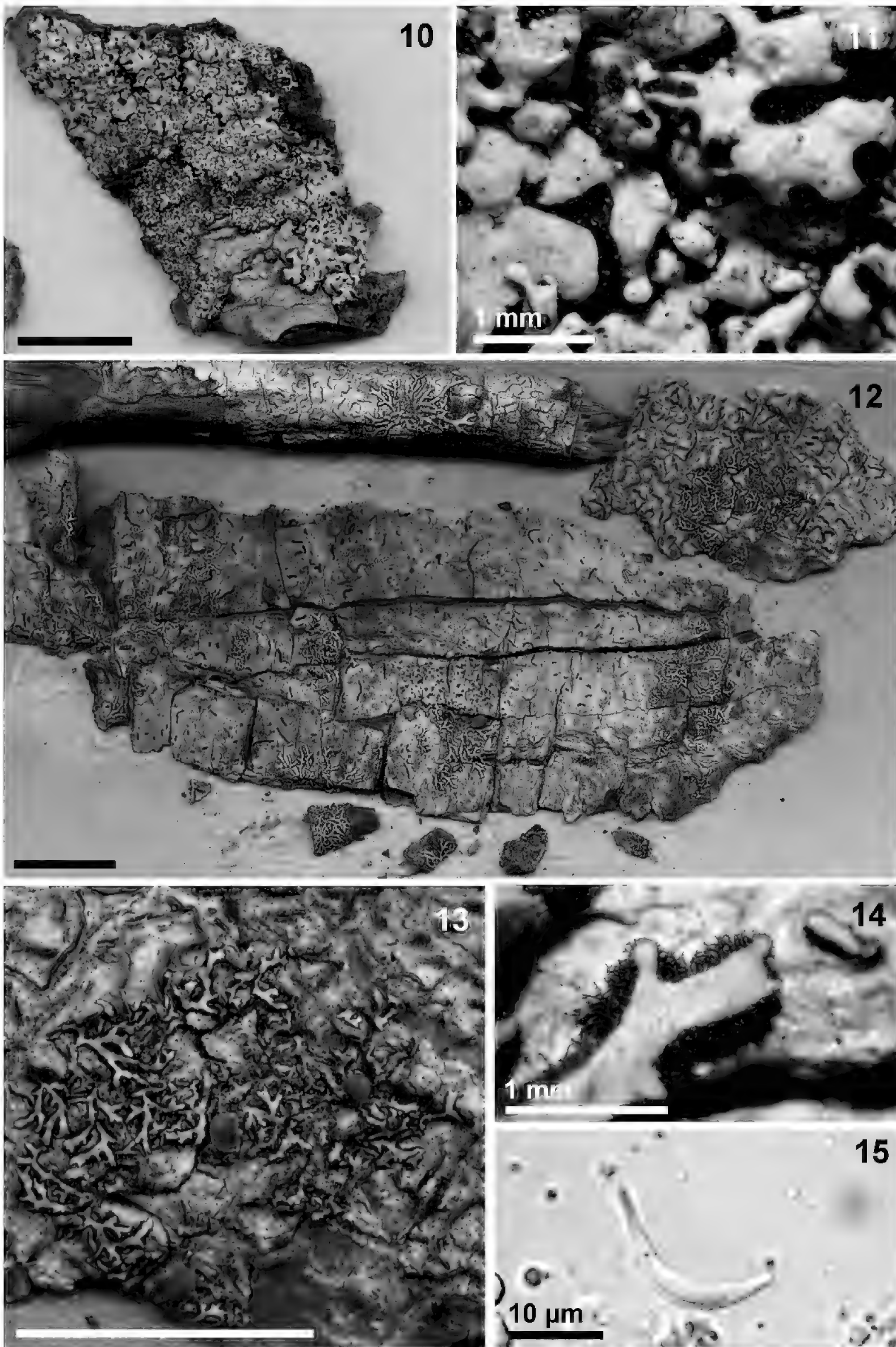
NOTES ON THE TYPE SPECIMEN. – The holotype is composed of three thalli from three different *Bulbothrix* species. When Fletcher (*in* Hale 1986) introduced the name *B. oliveirae* he cited the holotype type as “*L. Brako 5804*” and did not indicate whether he considered all three thalli to comprise a single specimen. Nonetheless, only a single thallus from the holotype was illustrated in the protologue, and this is the only thallus that corresponds to the description in the protologue. Thus it is assumed here that the remaining two thalli were not used to produce the description and should not be considered part of the type collection. The holotype thallus is in good condition with many pustules at different stages of development and erosion, but most of these structures were already in some stage of disintegration by the time of the collection. The specimen also lacks apothecia and pycnidia. The remaining two fragments represent thalli of *B. amazonensis* and *B. semilunata*, both in good condition. The three fragments present in the holotype were given the letters “a-c” at some point after collection, although no specific letter (i.e., thallus) was cited in the protologue.

COMMENTS. – Initially I suspected that *Bulbothrix oliveirae* and *B. leprieurii* might represent the same species, with the former representing a stage with pustulae still intact and barely formed soralia and the latter representing a stage with pustulae fully formed and several eroded soralia. After study of the available material it became clear that my impression was incorrect. Fletcher (*in* Hale 1986) misinterpreted all of the specimens cited in the protologue of *B. oliveirae*, except for the holotype, as having been pustulate rather than sorediate. In fact with the exception of the holotype which is pustulose, all specimens included in *B. oliveirae* by Fletcher (*in* Hale 1986) are sorediate and thus represent *B. leprieurii*. The differences between these two species are discussed in detail above in the entry for *B. leprieurii*. *Bulbothrix oliveirae* is superficially very similar to *B. leprieurii* and some specimens can be difficult to identify with certainty.

The formation of pustules is the main characteristic of *Bulbothrix oliveirae*. These structures can develop all over the upper cortex, but most often occur on the subapical parts of the laciniae and adventitious lacinulae. Initially they appear as swellings or warty bubbles, eventually bursting and gradually eroding, with their walls finally crumbling completely to leave only a hole in the medulla where the lower cortex is exposed. When the walls of the pustules crumble they sometimes form granular to subgranular structures that resemble soredia, but are actually thalline fragments composed of both tissue from both the cortex and medulla. These fragments are in fact coarse and partially corticate granules, and can be seen in varying quantities in the internal rim of the pustulae as they disintegrate.

The final stages of disintegration of the pustules usually leave a thin layer of medullary hyphae on top of the lower cortex, but there are times where this layer also fragments and fully exposes the black lower cortex. The damage caused to the thallus by the development of the pustules, appears to forcibly terminate the development of laciniae beyond that point. In the specimens examined there are relatively fewer pustulae in areas of the cortex where the laciniae or lacinulae continue to grow, which means that the pustulae are formed after the apices have formed new tissue at the growing edge. Propagules such as the soredia of *B. leprieurii*, the laminal lacinulae of *B. pseudocoronata*, or the common isidia found on about half of the species in the genus do not restrict the vegetative growth of the thallus in the manner that is seen in *B. oliveirae* (e.g., Benatti 2011a-b, 2012a-d, 2013a-c).





**Figures 10-15.** 10, holotype of *Bulbothrix oliveirae* (NY). 11, detail of the pustulae from the holotype of *B. oliveirae*. 12-15, holotype of *B. sipmanii* (U) showing overall appearance of the specimen (12), detail of laciniae and apothecia (13), detail showing the very narrow laciniae with contiguous bulbate cilia (14), and detail of the bicornute ascospores (15). Scale= 1 cm, except where noted.

The only other species of *Bulbothrix* known to produce pustules is *B. pustulata*. *Bulbothrix pustulata* differs by having wider laciniae (2.5–5.5 mm wide), a more fragile and delicate membranaceous thallus, pustules with a villous,  $\pm$  dactyloid aspect that often erupt but do not form of sores, less frequent cilia and rhizines with larger basal bulbs and simple apices, and by the presence of salazinic acid instead of gyrophoric acid in the medulla. The pustules of *B. pustulata* are also extensively produced throughout the upper cortex, instead of arising mainly on the apical portions of laciniae.

*Additional specimens examined* – **BRAZIL: SÃO PAULO:** Itanhaém Municipality, Balneário Santa Cruz, near the municipality border between Itanhaém and Peruíbe, low restinga wood ca. 500 m distant from the beach, 1 m alt., 24° 19'S, 47° 00'W, at vacant lots in an area being subdivided, on liana, 14.i.2004, *M.N. Benatti et al.* 1702 (SP); Cananéia Municipality, Base do Instituto Oceanográfico, 15.ii.1982, on palm tree near the sea coast, *M.P. Marcelli* 16296 (SP).

*Bulbothrix sipmanii* Aptroot & Aabel, Mycotaxon 71: 139. 1999.  
Mycobank #460386.

**TYPE: GUYANA:** East Demerara district, Tihmeri, Dakara Creek, Thompson's farm, ca. 10 m, coord. 6° 29'N, 58° 15'W, in cultivated, open area, on free standing tree, on branch, 2.ii.1985, *H. Sipman & A. Aptroot* 18032 (U! holotype; B!, TNS!, US! isotypes).

#### FIGURES 12, 13, 14 AND 15.

**DESCRIPTION.** – Thallus linear laciniate, dusky green in herbarium, up to 1.9 cm diam., submembranaceous, corticolous (on twigs), upper cortex 7.5–12.5  $\mu$ m thick, algal layer 10.0–12.5  $\mu$ m thick, medulla 15.0–20.0  $\mu$ m thick, lower cortex 7.5–10.0  $\mu$ m thick. Laciniae isotomic to anisotomic dichotomously to partially irregularly branched, 0.1–0.3 mm wide, contiguous to rarely slightly imbricate, very adnate and strongly appressed, with flat, truncate to acute apices, the margins plane, smooth to subirregular, entire to occasionally slightly incised, scarcely sublacinulate, the axils oval to irregular. Upper cortex smooth and continuous, laminal ciliary bulbs absent. Adventitious marginal lacinulae scarce on older parts, short, 0.1–0.3  $\times$  0.05–0.10 mm, flat, simple to rarely furcate, acute, lower side concolorous with the lower marginal zone. Maculae absent. Cilia black, apices initially simple or furcate, soon becoming very dichotomously branched 0.05–0.15 (–0.20)  $\times$  ca. 0.03 mm, with semi-immersed to sessile bulbate bases ca. 0.05 mm wide, abundant along the margins, contiguous, becoming absent or scarce only at the apices of the laciniae. Soredia and pustulae absent. Isidia scarce and disposed in small groups, laminal, granular to occasionally smooth cylindrical but still very short, straight, 0.05–0.10 (–0.20)  $\times$  ca. 0.05 mm, simple, erect, firm, concolorous with the cortex or with dark brownish apices, usually ciliate with small bulbs without apices or with very subtle ones. Medulla white. Lower cortex with variable coloration, brown to dark brown or partially blackish, slightly shiny to opaque, smooth, densely rhizinate. Marginal zone brown to dark brown in a narrow band ca. 0.5 mm wide, often hardly distinguishable from the center, slightly shiny, smooth, slightly less rhizinate than the center. Rhizines black to brown, initially furcate soon becoming very dichotomously branched, very intertwined, partially with subtle bulbate bases, 0.05–0.20  $\times$  0.03–0.05 mm, abundant but less dense near the margins, evenly distributed. Apothecia subconcave to convex, adnate to sessile, 0.2–1.6 mm diam., laminal, margins smooth, coronate (except at very early stages), amphithecia smooth, also with ciliary bulbs and occasionally with few isidia. Disc pale brown, epruinose, imperforate, epithecium 5.0–7.5  $\mu$ m alt., hymenium 25.0–35.0  $\mu$ m alt., subhymenium 25.0–35.0  $\mu$ m alt. Ascospores bicornute, crescent shaped or sigmoid, usually thicker at the apices restricting the lumen to the central portion, (10.0–) 13.0–18.5  $\times$  (2.5–) 3.0–4.0  $\mu$ m, epispore ca. 0.5  $\mu$ m. Pycnidia scarce, laminal, immersed, with black ostioles. Conidia bacilliform to weakly bifusiform, 5.0–7.5  $\times$  0.5  $\mu$ m.

**CHEMISTRY.** – Atranorin and gyrophoric acid (TLC/HPLC). Upper cortex K+ yellow, medulla K–, C+ and KC+ rose, UV–. Spot test reactions are somewhat difficult to interpret because of the thin medulla and very small size of many thalli.

**DISTRIBUTION.** – South America: Guyana (Aptroot & Aabel 1999).

NOTES ON THE TYPE SPECIMEN. – All the type material (holotype and isotypes) is composed of very small fragments, 1.0 to 2.0 cm in diameter, over tree bark, which are glued to backings. The very small size of the fragments and the very narrow, delicate and adnate laciniae render it quite difficult to observe the lower cortex without damaging the specimens. The material contains reasonably mature apothecia, although these are small, have coronation and some isidia, as well as mature ascospores. Pycnidia with conidia were also observed. The holotype has the best developed apothecia, where coronation can be easily seen, which is subtle or not perceptible in the isotypes because they are immature. The holotype also has a greater number of adventitious lacinulae.

COMMENTS. – Much like *Bulbothrix fungicola* and *B. linteolocarpa* Marcelli, this species has linear and very narrow laciniae, being among the smallest known in *Bulbothrix* species. Aptroot and Aubel (1999) described the laciniae width as 0.2–0.5 mm, although in all of the type material no single lacinia wider than 0.3 mm was found. As described by the authors, the larger laciniae tend to have truncated apices, while the smaller ones and the adventitious lacinulae tend to have more acute apices. As they are very narrow, it is difficult to separate laciniae in early stages of development from adventitious lacinulae, although the lacinulae usually have narrow bases and appear randomly on the margins. This characteristic is similar to *B. fungicola*.

The cilia and rhizines of *Bulbothrix sipmanii* tend to be dichotomously branched, assuming this form even in the very early stages of development, and are generally very short in length. Unlike the cilia, which are always dark, the rhizines can occasionally be brown and even paler than the lower surface. The marginal zone of the lower surface is sometimes difficult to distinguish from the center because it is partially dark brown in color, while the bases of the rhizines are paler, and partially bulbate. In the type material the lower surface was predominately brown and dark brown, but some laciniae had a black lower surface.

This species has very small and simple isidia, that are quite sparse and usually found solitary or in small groups that are randomly distributed on the upper surface. The isidia have brown apices as described by Aptroot and Aubel (1999), but in addition my examination revealed that the isidia become ciliate as they mature. The “blackened” apices in some of these isidia are actually ciliary bulbs in an early stage of development. These structures can be detected as small pointy apices, similar to those on marginal cilia near the apices of the youngest laciniae. This pattern of cilia growth on isidia is also similar to that which was observed in *B. fungicola* (see comments on this species above) and other *Bulbothrix* species with ciliate isidia.

*Bulbothrix sipmanii* was compared by Aptroot and Aubel (1999) to two other species, *B. schiffneri* Zahlbr.) Hale, which they believed to be the non-isidiate counterpart, and *B. semilunata*, which has similarly shaped of the ascospores. Of the four species of *Bulbothrix* with bicornute ascospores, *B. sipmanii* is the only one currently known to form vegetative propagules. As is the case for *B. schiffneri*, the apothecia of *B. sipmanii* have ciliary bulbs on the amphithecia, while the coronation of the margins is subtle on underdeveloped apothecia (different from other species that show clear coronation at the start of the apothecia maturation). *Bulbothrix schiffneri* is indeed very similar to *B. sipmanii* as it also contains gyrophoric acid. That species differs by the absence isidia, smaller ascospores (ca.  $8.0\text{--}13.0 \times 3.0\text{--}4.0 \mu\text{m}$  vs.  $13.0\text{--}18.5 \times 3.0\text{--}4.0 \mu\text{m}$  in *B. sipmanii*), and slightly wider laciniae (ca. 0.2–0.5 mm) (Benatti 2013c). *Bulbothrix semilunata* also differs from *B. sipmanii* by not forming isidia, and by the absence of medullary substances (Benatti 2013b). Thalli of *B. semilunata* have less branched cilia and rhizines (ranging from simple to furcate to partially subdichotomously branched) than those of *B. sipmanii* or *B. schiffneri*, which are generally furcate to very dichotomously branched, the apices presenting various continuous dichotomies. The tendency of the laciniae of *B. sipmanii* to have a brown lower cortex is also a difference with these species, which have a black lower cortex.

*Bulbothrix fungicola* is also similar to *B. sipmanii*, although it has wider laciniae (ca. 0.2–0.7 mm). When apothecia are lacking, *B. sipmanii* could be nearly indistinguishable from *B. fungicola*, due to the very small ciliate isidia which are present in both species. In direct comparison, the shape of the laciniae in *B. fungicola* tend to be more often sublinear, with more sinuous and crenate margins. The cilia and rhizines of *B. fungicola* are simple to furcate (not becoming dichotomously branched), and the lower surface is black with distinct brown margins. When apothecia are present the two species are easily distinguished because the apothecia of *B. fungicola* do not develop ciliary bulbs in the amphithecia, and the ascospores are ellipsoid or ovoid, instead of bicornute, as well as smaller ( $6.5\text{--}10.0 \times 4.5\text{--}6.0 \mu\text{m}$ ).

## SPECIES TREATED IN PREVIOUS CONTRIBUTIONS

***Bulbothrix papyrina* (Fée) Hale**, Phytologia 28(5): 480. 1974.  
Mycobank #341606.

DESCRIPTION. – For a description, discussion and images, see Benatti and Elix (2012).

COMMENTS. – This species was recently resurrected by Benatti and Elix (2012) who removed it from synonymy with *Bulbothrix goebelii*. It is characterized by laciniae 1.0–3.0 mm wide, an emaculate upper cortex, often pycnidiate tortuous isidia, dichotomously branched bulbate cilia and rhizines, a black lower surface with brown margins, occasionally pycnidiate but always ecoronate apothecia, and gyrophoric acid as only medullary substance.

The isidia of *Bulbothrix papyrina* often have embedded pycnidia, resembling black swellings, which were initially interpreted as parasites and later as ciliary bulbs. Occasionally, the pycnidia may also occur in small quantities on the amphithecia as well (the apothecia, however, are ecoronate, not having a bulbate rim). The pycnidiate isidia appear to be common, but not always present in *B. papyrina*. The production of pycnidia is likely a stage of development of the isidia and may even be triggered by environmental conditions.

***Bulbothrix pseudocoronata* (Gyeln.) Benatti & Marcelli**, Mycosphere 3(1): 49. 2012.  
Mycobank #561687.

DESCRIPTION. – For a description, comments and images, see Benatti 2012c.

Comments. – This species is characterized by having sublinear narrow laciniae (usually  $\leq 0.5$  mm wide), an emaculate upper cortex, dense semi-cylindrical to subcanaliculate or flat laminal lacinulae, simple or furcate cilia and rhizines, black lower surface with brown margins, rhizines with basal bulbs, coronate apothecia, small ascospores  $7.0\text{--}9.5 \times 4.5\text{--}5.5$   $\mu\text{m}$ , and by the presence of gyrophoric acid as the main medullary substance. It is the species that truly represents the concept of *Bulbothrix suffixa* established by Hale (1976), as the type of *B. suffixa* is a very poorly developed specimen that is impossible to identify with certainty (see description and comments under *B. suffixa* below).

***Bulbothrix pseudofungicola* Benatti & Marcelli**, Mycology 3(2): 127. 2012.  
Mycobank #561953.

DESCRIPTION. – For a description, discussion and images, see Benatti (2012a).

Comments. – This recently described species is characterized by narrow sublinear laciniae approximately 0.5–1.0 mm wide, an emaculate upper cortex, simple laminal isidia usually ornamented with small bulbate cilia, mostly dichotomously branched marginal cilia and rhizines, a black lower surface with brown margins, rhizines without basal bulbs, ecoronate apothecia, small rounded ascospores ( $4.0\text{--}6.0 \times 4.0\text{--}5.0$   $\mu\text{m}$ ), and the presence of gyrophoric acid. It is similar to *B. fungicola*, which has simple to furcate cilia and rhizines, coronate apothecia, and larger ascospores ( $8.0\text{--}10.0 \times 4.5\text{--}6.0$   $\mu\text{m}$ ).

***Bulbothrix scortella* (Nyl.) Hale**, Phytologia 28(5): 480. 1974.  
Mycobank #341610.

DESCRIPTION. – For a description, comments and images, see Benatti & Elix 2012.

Comments. – This species was recently resurrected in conjunction with establishing the true identity of *Bulbothrix goebelii* (Benatti & Elix 2012). It was one of several names originally recognized by Hale as distinct species, but later placed into synonymy with *B. goebelii* for unknown reasons. *Bulbothrix scortella* is characterized by laciniae approximately 0.5–1.5 mm wide, a maculate upper cortex, eciliate isidia, dichotomously branched bulbate cilia and rhizines, an entirely brown lower surface, ecoronate apothecia, and the presence of gyrophoric acid.



*Bulbothrix scortella* is similar to *B. subdissecta*, differing in the color of the lower surface, absence of lobaric acid as an accessory to gyrophoric acid and somewhat larger ascospores (ca.  $7.0\text{--}11.0 \times 4.0\text{--}5.0$   $\mu\text{m}$ ).

***Bulbothrix subdissecta* (Nyl.) Hale**, Phytologia 28(5): 480. 1974.  
Mycobank #341615.

DESCRIPTION. – For a description, discussion and images, see Benatti and Elix (2012).

Comments. – As with *Bulbothrix scortella*, this species was recently resurrected in a study dealing with the true identity of *B. goebelii*. It was one of several names that were initially treated as distinct species but then placed into synonymy with *B. goebelii* by Hale (see Benatti & Elix 2012).

This species is characterized by laciniae approximately 0.5–1.5 mm wide, a maculate upper cortex, eciliate isidia, dichotomously branched bulbate cilia and rhizines, a black lower surface with distinct brown margins, ecoronate apothecia, and presence of gyrophoric acid usually accompanied by lobaric acid. The species is similar to *B. scortella* and readers should refer to the discussion under that name for additional notes.

***Bulbothrix thomasiana* Benatti & Marcelli**, Biblioth. Lichenol. 106: 214. 2011.  
Mycobank #560776.

DESCRIPTION. – For a description, comments and images, see Marcelli et al. (2011).

Comments. – *Bulbothrix thomasiana* is one of the few species in *Bulbothrix* known to contain lobaric acid in the medulla, and together with *B. apophysata* and *B. goebelii* they are the only species known to have this as main medullary substance. This recently described species is characterized by narrow, sublinear laciniae, a smooth emaculate upper cortex, abundant, apically branched marginal bulbate cilia, simple and ciliate isidia, a usually pale brown lower surface with abundant concolorous rhizines, ecoronate apothecia with small ascospores, and the presence of lobaric acid. The most similar is *B. apophysata*, which differs in having a black lower surface with dark brown margins, dark rhizines, and completely eciliate isidia.

#### EXCLUDED OR DOUBTFUL NAMES

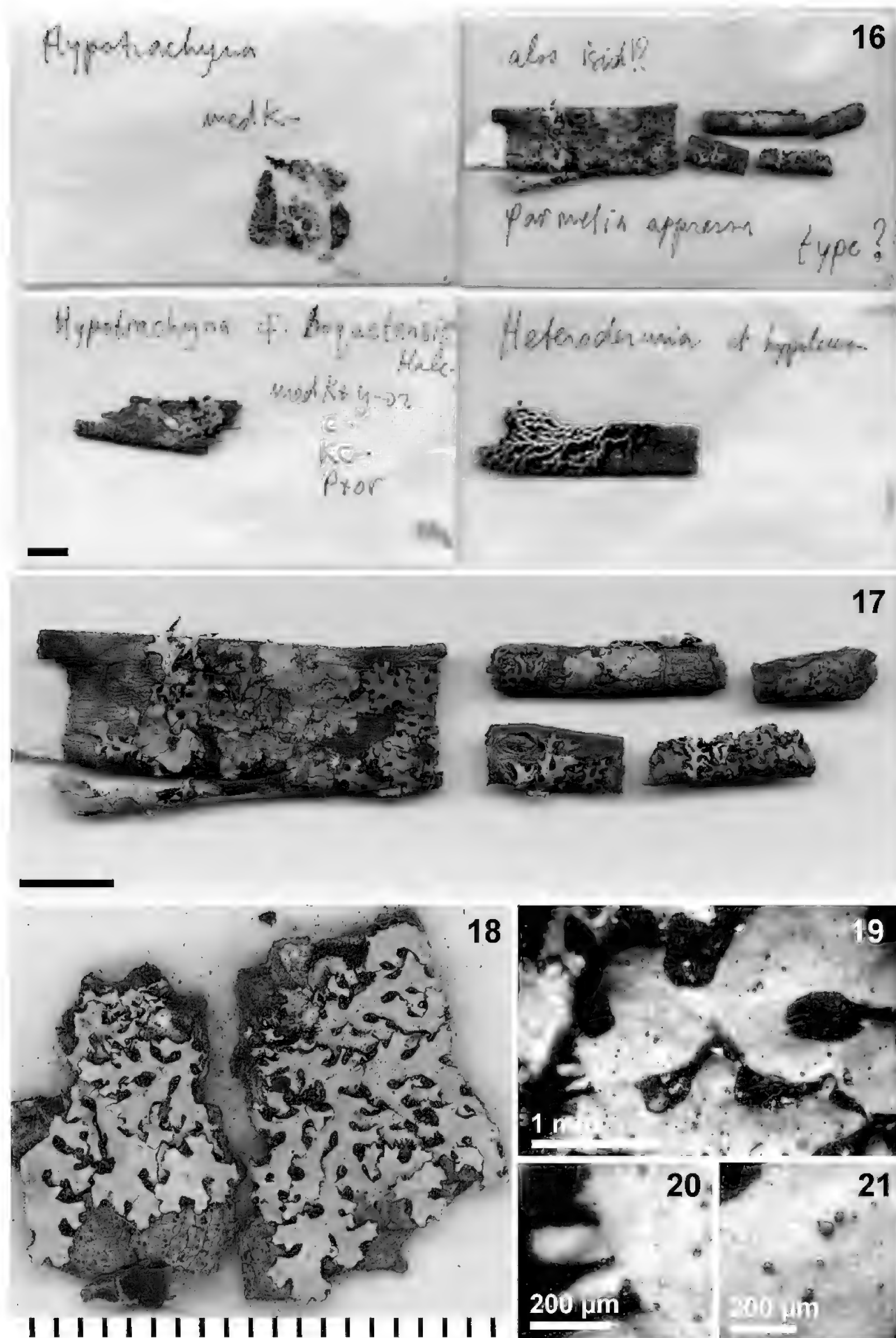
***Parmelia appressa* Zenker nom. illeg.**, in Goebel & Kunze, Pharmazeutische Waarenkunde 1: 157. 1827.  
(non *Parmelia appressa* Spreng.).  
Mycobank #368527

**TYPE: PERU:** locality and collector unknown (L!), holotype (as cited by Hale 1976).

#### FIGURE 16 AND 17.

Comments. – This name was correctly regarded as a *nomen illegitimum* according to DePriest (1999) as *Parmelia* “*appressa*” Zenker is a later homonym of *P. appressa* Spreng. It is worth noting that Zahlbuckner (1931 p. 704) treated *P. appressa* Spreng. as a synonym of *Physcia applanata* (Fée) Zahlbr. (= *Dirinaria applanata* (Fée) D. D. Awasthi).

The synonymy of *Parmelia* “*appressa*” with *Bulbothrix coronata* accepted by Hale (1976) is confusing because *B. coronata* has a black lower surface while Zenker (1827) described the lower surface of *P. “appressa”* as brown. Zenker (1827) mentioned the apothecia in this species as “contiguous, flattened, simple, small, usually with thalline margin and dark brown disks,” but there are no apothecia in the type material. In fact none of the fragments have any resemblance to the drawing of Zenker (1827: pl. 21, figs. 8A-E). All thalli in the type material also have many parasitic fungi. Without any apothecia to examine the coronation and ascospores, and due to the scarcity of isidia, it is impossible to determine whether *P. “appressa”* is conspecific with *B. coronata*, as was proposed by Hale (1976). Instead it may be an isidiate species distinct from *B. coronata* with a differently colored lower surface. It is also very similar to *B. klementii* Hale, differing mainly by the medullary chemistry. Another possibility is that it could correspond to *B. scortella*, which is also isidiate, with a brown lower surface and gyrophoric acid.



**Figures 16-21.** 16, all packets comprising the type collection of *Parmelia adpressa* (L). 17, Detail of the lectotype of *P. adpressa*. 18-21, lectotype of *Bulbothrix suffixa* (BM) showing overall appearance of the specimen (18), details of the upper cortex (19), scarce marginal adventitious lacinulae (20), and isidia (21). Scale bars = 1 cm, except where noted.

Fée (1837) also discussed material of *Parmelia* “*appressa*”, describing cortical maculae and a brown lower surface. Further details are lacking however, and I have not examined any specimens seen by Fée. It appears that he only summarized Zenker’s data in French. Meyen and Flotow (1843) described *P. “appressa”* as having a “whitish membranaceous thallus, sorediate, with a slightly apparent blackish felt hypothallus”. Their material almost certainly does not belong to the same species as the type, and if a hypothallus was present it might actually be a species of *Pannaria* or *Parmeliella*. Zahlbruckner (1931 p. 581) included Meyen and Flotow (1843) among the citations for *P. “appressa”* Zenker.

***Bulbothrix suffixa* (Stirt.) Hale**, *Phytologia* 28(5): 481. 1974.  
Mycobank #341618.

≡ *Parmelia suffixa* Stirt., *Scottish Naturalist* 4: 299. 1877–78. **TYPE: SOUTH AFRICA:** Knysna, 2.iv.1878 *J. Knobel s.n.* (BM!, lectotype (selected by Hale 1976); GLAM!, isoelectotype).

#### FIGURES 18, 19, 20 AND 21.

**DESCRIPTION (OF THE TYPES).** – Thallus sublinear laciniate, pale dusky gray in herbarium, fragments up to 2.0 cm diam., submembranaceous, corticolous, upper cortex 12.5–17.5 µm thick, algal layer 12.5–15.0 µm thick, medulla 17.5–25.0 µm thick, lower cortex 10.0–15.0 µm thick. Laciniae isotomic to anisotomic or irregularly dichotomously branched, 0.3–0.9 mm wide, contiguous to slightly imbricate, adnate and appressed, with flat, truncate to subtruncate apices, the margins plane, smooth to sinuous, subcrenate or irregular, entire to slightly incised, frequently sublacinulate, the axils oval or rounded. Upper cortex smooth and continuous, laminal ciliary bulbs absent. Adventitious marginal or very rarely submarginal lacinulae common on random parts but more often at older parts, short, 0.15–0.50 × 0.05–0.15 mm, spatuliform, simple to rarely furcate, truncate to subtruncate, initially eciliate but soon developing small marginal ciliary bulbs, lower side concolorous with the lower marginal zone. Maculae weak, almost indistinct, laminal, more visible at younger parts, mixed with scars left by fallen isidia. Cilia black, apices initially simple to furcate, occasionally becoming subdichotomously branched at the axils, 0.05–0.30 (–0.45 at the axils) × ca. 0.03 mm, commonly bent downwards, with semi-immersed to sessile bulbate bases 0.05–0.10 (–0.15) mm wide, abundant along the margins spaced ca. 0.05 mm from each other eventually becoming contiguous, becoming absent only at the apices of the laciniae. Soredia and pustulae absent. Isidia scarce, laminal, granular to smooth cylindrical, very short (apparently at initial stages of development), straight, ca. 0.05 (–0.10) × ca. 0.05 mm, simple, erect, firm, darkened, partially ciliate with tiny bulbs. Medulla white. Lower cortex black to brown or dark castaneous brown, shiny, smooth to subrugose, weakly papillate, densely rhizinate. Marginal zone brown to dark castaneous brown in a narrow band ca. 0.5–1.5 mm wide, shiny to opaque, smooth, weakly papillate, moderate to densely rhizinate. Rhizines black, partially dark brown near the margins or until the transition to the center, initially simple or furcate soon becoming subdichotomously or irregularly branched, commonly with bulbate bases, 0.10–0.50 × ca. 0.03 mm, frequent to abundant almost like a tomentum at some parts, evenly distributed. Apothecia and pycnidia not found.

**CHEMISTRY.** – Atranorin and gyrophoric acid (TLC/HPLC). Upper cortex K+ yellow, medulla K–, C+ and KC+ rose to reddish rose, UV–.

**DISTRIBUTION (SUMMARY OF THE LITERATURE).** – Africa and South Atlantic Islands: South Africa (Dodge 1959, Hale 1976, Stirton 1878), Saint Helena (Dodge 1959), Mauritius (Hale 1976), Kenya (Swinscow & Krog 1988), Madagascar (Aptroot 1990). Central America and Caribbean: Dominican Republic, Guatemala, Honduras, Cuba, Dominica, Jamaica, Saint Lucia (Hale 1976), Costa Rica (Breuss 2001, Nöske & Sipman 2004). South America: Guyana (Feüerer 2008), Venezuela (Hale 1976, López-Figueiras 1986, Marcano et al. 1996) and Brasil (Brako et al. 1985, Eliasaro 2001, Fleig & Riquelme 1991, Jungbluth 2006, Marcelli 1993). It is possible that most of these specimens belong in truth to *Bulbothrix pseudocoronata*, or even another laminally lacinulate species (see comments below).

**NOTES ON THE TYPE SPECIMENS:** The lectotype consists of two fragments, each approximately 1.5 cm in diameter, which are on tree bark. The material is in good condition, very little damaged, and has

fairly common marginal adventitious lacinulae, with some sparse submarginal ones close to the margins. The duplicate in GLAM also consists of two fragments, one of 2 cm and the other only 1 cm in diameter, in the same conditions as the lectotype, but with more marginal lacinulae, with some few submarginal ones restricted to a few laciniae. Although the specimens are in good condition, the material is very poorly developed with thalli in the early stages of propagule formation.

Comments. – *Bulbothrix suffixa* is here considered to be a *nomen dubium* because the type material is very small and immature. It has sublinear narrow laciniae, a weakly maculate upper cortex, small adventitious marginal and (rarely) submarginal lacinulae, simple to little branched cilia, a black to brown lower surface with brown margins, branched rhizines with bulbate bases, and gyrophoric acid. Even though these characters could be ascertained, the poor development of other structures makes application of the name uncertain.

The protologue of *Parmelia suffixa* (Stirton 1878) does not mention any lobules, lacinulae, or other similar structure of vegetative propagation. However, there are small structures on the cortex of the type material that resemble undeveloped isidia, occasionally with some small ciliary bulbs. Initially I thought that these isidium initials were the beginning stages of structures that ultimately develop into lacinulae which function as vegetative propagules. There is however, no evidence that this is the case as the lacinulae developed on the thallus are identical to those on the margins which lack the brownish apices of the immature isidia. These structures appear merely to be regenerating parts of the thallus and are not easily detached, thus they are unlikely to function as vegetative diaspores. Due to the poor state of the type material it is impossible to ascertain with certainty what the morphological characteristics of *Bulbothrix suffixa* are. It is unclear whether the poorly developed structures are akin to the isidia in *B. fungicola*, the laminal lacinulae in *B. pseudocoronata*, or, however unlikely it may be, whether they represent isidia that transform into lacinulae. There are also no apothecia or pycnidia in the type material that would further facilitate identification.

Dodge (1959) attributed specimens to *Bulbothrix suffixa*, but his descriptions were mainly anatomical and not morphological, which make comparison with other species nearly impossible. He even described the material as eciliate, although he mentioned that the specimens seemed ciliate due the presence of simple to branched rhizines, which apparently spilled from the margins. Dodge did not mention lobules, lacinulae or any other similar structure. The apothecia were just described as “smooth”, which might imply the absence of bulbate cilia (coronation). The ascospores were described as ellipsoid and  $13.0\text{--}14.0 \times 6.0\text{--}8.0 \mu\text{m}$  in size, similar to those mentioned by Krog and Swinscow (1988) for specimens they also identified as *B. suffixa*.

The beginning of the modern application of this name likely dates to Hale (1976) where it was described having an upper cortex “becoming densely lobulate, lobules dorsiventral, oblong to spatuliform, marginally bulbate-ciliate”. Neither the description nor the illustration in Hale (1976) correspond to the same species as the type material of *B. suffixa*. The photograph used in that work to illustrate *B. suffixa* corresponds very well to *B. pseudocoronata*, which was considered a synonym of *B. fungicola* by Hale (1976).

## II: WORLD KEY TO THE GENUS BULBOTHRIX

- 1a. Upper cortex yellowish green, with usnic acid (K–) ..... *Relicina*
- 1b. Upper cortex greenish gray to grayish, with atranorin (K+ yellow) ..... 2
- 2a. Thallus isidiate, lacinulate, sorediate or pustulate ..... 3
- 3a. Thallus sorediate or pustulate ..... 4
- 4a. Thallus pustulate, pustulae sometimes bursting, forming granular soredia ..... 5
- 5a. Laciniae 2.5–5.5 mm wide; cilia and rhizines simple; pustulae rugose to dactyloid; medulla K+ yellow→dark red, P+ yellow (salazinic acid) ..... *B. pustulata*
- 5b. Laciniae 0.5–1.5 mm wide; cilia and rhizines dichotomous; pustulae forming small warts; medulla C+ rose, KC+ rose→light orange (gyrophoric acid) ..... *B. oliveirae*
- 4b. Thallus sorediate, soralia orbicular to irregular ..... 6



- 6a.** Laciniae 2.0–4.5 mm wide; cilia and rhizines simple; medulla K+ yellow→dark red, P+ orange (salazinic acid) ..... *B. imshaugii*
- 6b.** Laciniae 0.3–0.7 mm wide; cilia and rhizines dichotomous; medulla C+ rose, KC+ rose →light orange (gyrophoric acid) ..... *B. lepriurii*
- 3b.** Thallus isidiate and/or lacinulate ..... 7
- 7a.** Thallus lacinulate; lacinulae dorsiventral and procumbent, flattened to canaliculate or semicylindric (like cleaved isidia), ciliate and eventually becoming rhizinate ..... 8
- 8a.** Laciniae 1.0–1.5 (–3.0) mm wide; lacinulae plane to subconvex, dichotomous or irregularly branched; cilia dichotomous or irregularly branched; apothecia ecoronate (fatty acids, all spot tests negative)..... *B. lopezii*
- 8b.** Laciniae 0.2–1.0 mm wide; lacinulae semicylindric to canaliculate, simple to furcate; cilia simple to furcate, rarely subdichotomous; apothecia coronate..... 9
- 9a.** Laciniae 0.2–0.5 mm wide; lacinulae often semicylindric with isidiate aspect at early stages, resembling cleaved isidia and eventually becoming canaliculate; medulla C+ rose, KC+ rose→light orange (gyrophoric acid)..... *B. pseudocoronata*
- 9b.** Laciniae 0.3–1.0 mm wide; lacinulae generally flattened from the beginning of their development; medulla with all tests negative (no substances) ..... *B. caribensis*
- 7b.** Thallus isidiate; isidia cylindrical and erect, occasionally subirregular, with or without bulbate cilia of irregular and random disposition ..... 10
- 10a.** All medullary spot tests negative (without medullary substances or with colensoinic acid)..... 11
- 11a.** Laciniae subirregular, 1.5–3.0 mm wide; cilia mainly axillary and on incisions, apices simple or absent; rhizines simple; isidia often partially pycnidiate..... *B. cassa*
- 11b.** Laciniae sublinear, 0.2–1.0 (–1.5) mm wide; cilia conspicuously marginal, apices initially simple to eventually branched; rhizines branched; isidia never pycnidiate..... 12
- 12a.** Upper cortex maculate; laminal ciliar bulbs frequent; cilia simple becoming furcate or trifurcate (isidia usually ciliate)..... *B. queenslandica*
- 12b.** Upper cortex emaculate; laminal ciliar bulbs absent; cilia furcate becoming dichotomous or irregularly branched..... 13
- 13a.** Laciniae 0.5–1.0 mm wide; lower cortex with brown center and margins; medulla with colensoinic acid (TLC/HPLC) ..... *B. klementii*
- 13b.** Laciniae 0.2–0.7 mm wide; lower cortex with a black center and brown margins; medulla with traces or without any substances (TLC/HPLC) ..... 14
- 14a.** Isidia eciliate; medulla, lower cortex and rhizines with randomly placed spots of a reddish K– pigment; medulla often with traces of gyrophoric acid ..... *B. pigmentacea*
- 14b.** Isidia ciliate; medulla, lower cortex and rhizines without any pigments; medulla often with traces of an undetermined fatty acid ..... *B. lyngei*
- 10b.** At least one positive medullary spot test reaction (gyrophoric, lecanoric, lobaric, norstictic or salazinic acids) ..... 15
- 15a.** Medulla K+ yellow→orange, bright or dark red, P+ yellow or orange, with norstictic or salazinic acids ..... 16
- 16a.** Medulla K+ yellow→orange or bright red, P+ yellow, with norstictic acid (small acicular star shaped reddish orange microcrystals formed in KOH)..... 17
- 17a.** Laciniae 0.3–0.6 mm wide; cilia initially simple, becoming furcated or subdichotomous; lower cortex with black center and brown margins; rhizines dichotomously branched ..... *B. lordhowensis*
- 17b.** Laciniae 0.5–4.5 mm wide; cilia simple or without apices; lower cortex predominantly brown or variably mottled black and brown; rhizines simple ..... 18

- 18a.** Thallus corticolous; laciniae subirregular, 1.5–3.0 (–4.5) mm wide; laminal ciliar bulbs common, varying from scarce to abundant; isidia concolorous; lower cortex with variable color, from black to mixed black and brown or totally brown ..... *B. ventricosa*
- 18b.** Thallus saxicolous; laciniae sublinear, 0.5–1.5 (–2.5) mm wide; laminal ciliary bulbs absent; isidia dark brown or blackish; lower cortex pale brown, sometimes the margins darker than the center ..... *B. cinerea*
- 16b.** Medulla K+ yellow→dark red, P+ orange, with salazinic acid (depending on the concentration, bundles of dark red microcrystals might be formed in KOH)..... **19**
- 19a.** Upper cortex very cracked, eventually shedding small pieces (strongly maculate); cilia and rhizines dichotomous; isidia ciliate ..... *B. subtabacina*
- 19b.** Upper cortex continuous or with few irregular cracks, never shedding pieces (emaculate or maculate); cilia and rhizines simple; isidia eciliate ..... **20**
- 20a.** Lower cortex black, with black or brown margins, sometimes with small randomly placed dark brown spots..... **21**
- 21a.** Thallus solely saxicolous; laciniae 0.5–3.0 mm wide, with subtruncate apices and sinuous margins; upper cortex emaculate, with frequent cracks; isidia blackish; cilia with simple or absent apices..... *B. decurtata*
- 21b.** Thallus usually corticolous (rarely saxicolous); laciniae 1.5–5.5 mm wide, with rounded apices and crenate margins; upper cortex weakly to moderately maculate, continuous; isidia concolorous; cilia with simple or double apices ..... *B. tabacina*
- 20b.** Lower cortex usually uniformly brown (could have variable shades), occasionally with small random blackish spots ..... **22**
- 22a.** Laciniae 0.1–2.0 mm wide, with subtruncate apices and sinuous margins; marginal cilia abundant to contiguous (upper cortex maculate or emaculate) ..... **23**
- 23a.** Laciniae 0.1–0.5 mm wide; lower cortex dark brown..... *B. microscopica*
- 23b.** Laciniae 0.5–2.0 mm wide; lower cortex brown to pale brown..... **24**
- 24a.** Upper cortex emaculate; isidia usually 0.5–1.0 mm high, generally simple; lower cortex brown with an average tone ..... *B. australiensis*
- 24b.** Upper cortex maculate; isidia usually < 0.5 mm high, commonly branched; lower cortex very pale brown ..... *B. subglandulifera*
- 22b.** Laciniae 1.5–5.5 mm wide, with subrounded apices and crenate margins; cilia mainly axillary and in the crenulae of the laciniae (upper cortex maculate)..... **25**
- 25a.** Thallus corticolous, submembranaceous; upper cortex weakly to densely maculate; cilia with short apices < 0.3 mm long; rhizines without bulbs ..... *B. isidiza*
- 25b.** Thallus saxicolous, coriaceous; upper cortex emaculate; cilia with long apices ≥ 0.3 mm long; rhizines with basal or displaced bulbs..... *B. subscortea*
- 15b.** Medulla C+ rose to reddish and/or KC+ rose to reddish, with gyrophoric, lecanoric and/or lobaric acids..... **26**
- 26a.** Medulla C–, KC+ rose, UV+ bluish to whitish blue, only lobaric acid..... **27**
- 27a.** Isidia eciliate; lower cortex black with variably brown margins..... *B. apophysata*
- 27b.** Isidia usually ciliate; lower cortex entirely pale brown ..... *B. thomasiana*
- 26b.** Medulla C+ and KC+ rose to reddish→light orange, with gyrophoric and/or lecanoric acids, sometimes also containing lobaric acid ..... **28**
- 28a.** Medulla C+ and KC+ distinctly reddish, with lecanoric acid\* ..... **29**

- 29a.** Upper cortex, apothecia and isidia eciliate; isidia sometimes with apical portion lost, similar to a pseudocyphellum ..... *B. laevigatula*
- 29b.** Upper cortex, apothecia and isidia ciliate; isidia entire ..... *B. bulbilosa*
- 28b.** Medulla C+ and KC+ rose to reddish rose, with gyrophoric acid, with or without lobaric acid (isidia always entire) ..... **30**
- 30a.** Laciniae 0.1–0.7 mm wide; isidia usually ciliate ..... **31**
- 31a.** Laciniae 0.1–0.3 mm wide; lower cortex mottled black and dark brown; ascospores bicornute,  $12.0\text{--}18.0 \times 3.0\text{--}4.0 \mu\text{m}$ ..... *B. sipmanii*
- 31b.** Laciniae 0.2–0.7 mm wide; lower cortex black with brown margins; ascospores ellipsoid,  $8.0\text{--}10.0 \times 4.0\text{--}6.0 \mu\text{m}$  ..... **32**
- 32a.** Cilia and rhizines simple to furcate; apothecia coronate; ascospores ellipsoid  $8.0\text{--}10.0 \times 4.5\text{--}6.0 \mu\text{m}$ ..... *B. fungicola*
- 32b.** Cilia and rhizines dichotomous; apothecia ecoronate; ascospores rounded  $4.0\text{--}6.0 \times 4.0\text{--}5.0 \mu\text{m}$  ..... *B. pseudofungicola*
- 30b.** Laciniae 0.5–3.0 mm wide; isidia eciliate ..... **33**
- 33a.** Laciniae 1.0–3.0 mm wide; upper cortex emaculate; isidia straight to tortuous and frequently pycnidiate, amphithecium also sometimes pycnidiate; medulla containing only gyrophoric acid ..... *B. papyrina*
- 33b.** Laciniae 0.5–1.0 mm wide; upper cortex maculate; isidia only straight, amphithecium never pycnidiate; medulla usually containing gyrophoric and lobaric acids (UV+ faint bluish) ..... **34**
- 34a.** Lower cortex light brown, margins often darker than the center; ascospores  $(6.0\text{--}) 7.0\text{--}11.0 \text{ (–}12.5) \times 4.0\text{--}6.0 \mu\text{m}$  (some specimens might present only medullary gyrophoric acid) ..... *B. scortella*
- 34b.** Lower cortex black, with dark brown margins and sometimes also a few random spots; ascospores  $(5.0\text{--}) 6.0\text{--}8.0 \text{ (–}9.0) \times 4.0\text{--}5.0 \mu\text{m}$  (specimens always with both the gyrophoric and lobaric acids) ..... *B. subdissecta*
- 2b.** Thallus without vegetative propagules or pustulae; apothecia often formed ..... **35**
- 35a.** All medullary spot tests negative (medulla without substances, with fatty acids or substances concentrated at the medulla of the apothecia) ..... **36**
- 36a.** Lower cortex light brown margins sometimes darker than the center; apothecia with amphithecial bulbs and also occasionally with pycnidia ..... *B. subklementii*
- 36b.** Lower cortex black, with black or brown margins; apothecia with smooth amphithecia, without bulbs or pycnidia ..... **37**
- 37a.** Apothecia coronate ..... **38**
- 38a.** Laciniae 0.2–0.5 mm wide; ascospores bicornute,  $12.0\text{--}23.0 \times 3.0\text{--}4.0 \mu\text{m}$  ..... *B. semilunata*
- 38b.** Laciniae 0.5–2.5 mm wide; ascospores rounded,  $4.5\text{--}6.0 \times 4.0\text{--}5.0 \mu\text{m}$  ..... **39**
- 39a.** Laciniae (1.0–) 1.5–2.5 mm wide; laminal ciliar bulbs common, frequent; cilia apices simple to furcate; rhizines subdichotomous ..... *B. bulbochaeta*
- 39b.** Laciniae 0.5–1.0 (–1.5) mm wide; laminal ciliar bulbs absent; cilia apices simple or absent; rhizines usually simple ..... *B. viridescens*
- 37b.** Apothecia ecoronate ..... **40**
- 40a.** Laminal ciliar bulbs absent; cilia and rhizines dichotomously branched; rhizines commonly brown; apothecia medulla KC+ lilaceous, UV+ faint blue (lobaric acid); ascospores  $4.0\text{--}6.0 \text{ (–}7.0) \times 4.0\text{--}5.0 \mu\text{m}$  ..... *B. goebelii*
- 40b.** Laminal ciliar bulbs common, also frequent in the amphithecia (not true corona); cilia apices simple or absent; rhizines simple to irregularly branched, black; apothecia medulla KC– and UV–; ascospores  $6.0\text{--}9.0 \times 4.0\text{--}5.0 \mu\text{m}$  ..... *B. laeviuscula*

<b>35b.</b> Medullary spot tests positive, C+ and KC+, K+ and P+, or KC+ and P+ (gyrophoric, lecanoric, norstictic, protocetraric or salazinic acids).....	<b>41</b>
<b>41a.</b> Medulla K– and C–, KC+ rose, P+ orange, with protocetraric acid .....	<b><i>B. chowoensis</i></b>
<b>41b.</b> Medulla K– and P–, C+ and KC+ rose to reddish, or C– and KC–, K+ yellow→orange or red and P+ yellow to orange, with other substances .....	<b>42</b>
<b>42a.</b> Medulla K– and P–, C+ and KC+ rose to reddish, gyrophoric or lecanoric acids .....	<b>43</b>
<b>43a.</b> Cilia and rhizines usually simple, sometimes partially furcate (apothecia coronate, medulla with gyrophoric acid) .....	<b>44</b>
<b>44a.</b> Thallus corticolous; laciniae 0.5–1.1 mm wide; ascospores 8.0–10.0 × 4.0–5.0 µm.....	<b><i>B. affixa</i></b>
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\* a chemotype of *Bulbothrix bulbillosa* containing gyrophoric acid is morphologically identical to the one containing lecanoric acid. This is a very peculiar and unique case in *Bulbothrix*, as even the spot test reactions to C and KC on *B. bulbillosa* are usually bright red for the specimens containing gyrophoric acid (what is normally expected for lecanoric acid) instead of pale pink (the usual for gyrophoric acid).

### III: INDEX TO CURRENTLY ACCEPTED NAMES IN BULBOTHRIX

Year	Original name	Current status
1824	<i>Parmelia coronata</i> Fée	<i>Bulbothrix coronata</i> (Fée) Hale
1824	<i>Parmelia glandulifera</i> Fée	≡ <i>B. coronata</i> (Fée) Hale
1827	<i>Parmelia appressa</i> Zenker	<i>Nomen illegitimum</i>
1827	<i>Parmelia goebelii</i> Zenker	<i>Bulbothrix goebelii</i> (Zenker) Hale
1837	<i>Parmelia papyrina</i> Fée	<i>Bulbothrix papyrina</i> (Fée) Hale
1847	<i>Parmelia hookeri</i> Taylor	≡ <i>B. laevigatula</i> (Nyl.) Hale
1856	<i>Parmelia tabacina</i> Mont. & Bosch	<i>Bulbothrix tabacina</i> (Mont. & Bosch) Hale
1860	<i>Parmelia tiliacea</i> var. <i>meizospora</i> Nyl.	<i>Bulbothrix meizospora</i> (Nyl.) Hale
1869	<i>Parmelia meizospora</i> (Nyl.) Nyl.	<i>Bulbothrix meizospora</i> (Nyl.) Hale
1878	<i>Parmelia amplexans</i> Stirton	≡ <i>Bulbothrix meizospora</i> (Nyl.) Hale
1878	<i>Parmelia suffixa</i> Stirton	<i>Bulbothrix suffixa</i> (Stirt.) Hale / <i>Nomen dubium</i>
1884	<i>Parmelia isidiza</i> Nyl.	<i>Bulbothrix isidiza</i> (Nyl.) Hale
1884	<i>Parmelia meizospora</i> var. <i>isidiosa</i> Müll. Arg.	<i>Nomen nudum</i>
1884	<i>Parmelia subdissecta</i> Nyl.	<i>Bulbothrix subdissecta</i> (Nyl.) Hale
1885	<i>Parmelia atrichella</i> Nyl.	<i>Bulbothrix atrichella</i> (Nyl.) Hale
1885	<i>Parmelia granatensis</i> Nyl.	≡ <i>B. papyrina</i> (Fée) Hale
1885	<i>Parmelia laevigatula</i> Nyl.	<i>Bulbothrix laevigatula</i> (Nyl.) Hale

1885	<i>Parmelia scortella</i> Nyl.	<i>Bulbothrix scortella</i> (Nyl.) Hale
1887	<i>Parmelia subcoronata</i> Müll. Arg.	<i>Bulbothrix subcoronata</i> (Müll. Arg.) Hale
1888	<i>Parmelia coronata</i> f. <i>isidiosa</i> Müll. Arg.	≡ <i>Bulbothrix pseudocoronata</i> (Gyeln.) Benatti & Marcelli
1891	<i>Parmelia bicornuta</i> Müll. Arg.	<i>Bulbothrix bicornuta</i> (Müll. Arg.) Hale
1893	<i>Parmelia stenophylla</i> Müll. Arg.	<i>Nomen inquirendum</i>
1894	<i>Parmelia tiliacea</i> var. <i>hypoleuca</i> Müll. Arg.	≡ <i>Bulbothrix isidiza</i> (Nyl.) Hale
1899	<i>Parmelia subglandulifera</i> Hue	<i>Bulbothrix subglandulifera</i> (Hue) Hale
1901	<i>Parmelia coronata</i> var. <i>denudata</i> Vain.	≡ <i>Bulbothrix affixa</i> (Hale & Kurok.) Hale
1901	<i>Parmelia hypocraea</i> Vain.	<i>Bulbothrix hypocraea</i> (Vainio) Hale
1907	<i>Parmelia addenda</i> Vain.	≡ <i>Bulbothrix papyrina</i> (Fée) Hale
1909	<i>Parmelia acariospora</i> Zahlbr.	≡ <i>Bulbothrix papyrina</i> (Fée) Hale
1909	<i>Parmelia schiffneri</i> Zahlbr.	<i>Bulbothrix schiffneri</i> (Zahlbr.) Hale
1914	<i>Parmelia continua</i> Lynge	<i>Bulbothrix continua</i> (Lynge) Hale
1914	<i>Parmelia fungicola</i> Lynge	<i>Bulbothrix fungicola</i> (Lynge) Hale
1914	<i>Parmelia marginalis</i> Lynge	≡ <i>Bulbothrix scortella</i> (Nyl.) Hale
1914	<i>Parmelia semilunata</i> Lynge	<i>Bulbothrix semilunata</i> (Lynge) Hale
1914	<i>Parmelia viridescens</i> Lynge	<i>Bulbothrix viridescens</i> (Lynge) Hale
1915	<i>Parmelia isidiza</i> var. <i>domingensis</i> Vain.	≡ <i>Bulbothrix ventricosa</i> (Hale & Kurok.) Hale
1926	<i>Parmelia leptascea</i> Stein. & Zahlbr.	≡ <i>Bulbothrix hypocraea</i> (Vain.) Hale
1926	<i>Parmelia sensibilis</i> Stein. & Zahlbr.	<i>Bulbothrix sensibilis</i> (Stein. & Zahlbr.) Hale
1928	<i>Parmelia demangei</i> Harmand	<i>Nomen inquirendum</i>
1928	<i>Parmelia recurviscens</i> Harmand	<i>Nomen inquirendum</i>
1928	<i>Parmelia ochrovestita</i> Zahlbr.	≡ <i>Bulbothrix tabacina</i> (Mont. & Bosch) Hale
1930	<i>Parmelia setschwanensis</i> Zahlbr.	<i>Bulbothrix setschwanensis</i> (Zahlbr.) Hale
1930	<i>Parmelia stenophyllizans</i> Zahlbr.	Nomina inquirenda
1931	<i>Parmelia pseudocoronata</i> Gyelnik	<i>Bulbothrix pseudocoronata</i> (Gyeln.) Benatti & Marcelli
1938	<i>Parmelia proboscidea</i> var. <i>saxicola</i> Sambo	≡ <i>Bulbothrix hypocraea</i> (Vain.) Hale
1947	<i>Parmelia marginalis</i> var. <i>laeviuscula</i> Räsänen	<i>Bulbothrix laeviuscula</i> (Räsänen) Benatti & Marcelli
1957	<i>Parmelia subscortea</i> Asahina	<i>Bulbothrix subscortea</i> (Asahina) Marcelli & Benatti
1959	<i>Parmelia gillettii</i> Dodge	≡ <i>Bulbothrix isidiza</i> (Nyl.) Hale
1959	<i>Parmelia meizosporoides</i> Dodge	≡ <i>Bulbothrix tabacina</i> (Mont. & Bosch) Hale
1959	<i>Parmelia njalensis</i> Dodge	≡ <i>Bulbothrix scortella</i> (Nyl.) Hale
1959	<i>Parmelia sublaevigatoides</i> Dodge	≡ <i>Bulbothrix tabacina</i> (Mont. & Bosch) Hale

1961	<i>Parmelia confoederata</i> W.L. Culb.	<i>Bulbothrix confoederata</i> (W.L. Culb.) Hale
1964	<i>Parmelia bulbochaeta</i> Hale	<i>Bulbothrix bulbochaeta</i> (Hale) Hale
1964	<i>Parmelia pustulata</i> Hale	<i>Bulbothrix pustulata</i> (Hale) Hale
1964	<i>Parmelia affixa</i> Hale & Kurok.	<i>Bulbothrix affixa</i> (Hale & Kurok.) Hale
1964	<i>Parmelia apophysata</i> Hale & Kurok.	<i>Bulbothrix apophysata</i> (Hale & Kurok.) Hale
1964	<i>Parmelia ventricosa</i> Hale & Kurok.	<i>Bulbothrix ventricosa</i> (Hale & Kurok.) Hale
1964	<i>Parmelia decurtata</i> Kurok.	<i>Bulbothrix decurtata</i> (Kurok.) Hale & Kurok.
1965	<i>Parmelia subinflata</i> Hale	<i>Parmelinopsis subinflata</i> (Hale) Benatti & Marcelli
1968	<i>Parmelia pigmentacea</i> Hale	<i>Bulbothrix pigmentacea</i> (Hale) Hale
1971	<i>Parmelia imshaugii</i> Hale	<i>Bulbothrix imshaugii</i> (Hale) Hale
1972	<i>Parmelia chowoensis</i> Hale	<i>Bulbothrix chowoensis</i> (Hale) Hale
1972	<i>Parmelia enormis</i> Hale	<i>Bulbothrix enormis</i> (Hale) Krog
1974	<i>Bulbothrix continua</i> (Lynge) Hale	-
1974	<i>Bulbothrix papyrina</i> (Fée) Hale	-
1974	<i>Bulbothrix scortella</i> (Nyl.) Hale	-
1974	<i>Bulbothrix subdissecta</i> (Nyl.) Hale	-
1974	<i>Bulbothrix subglandulifera</i> (Hue) Hale	-
1974	<i>Parmelina enormis</i> (Hale) Hale	≡ <i>Bulbothrix enormis</i> (Hale) Krog
1976	<i>Bulbothrix klementii</i> Hale	-
1979	<i>Parmelia subtabacina</i> Elix	<i>Bulbothrix subtabacina</i> (Elix) Elix
1979	<i>Parmelia queenslandica</i> Elix & Stevens	<i>Bulbothrix queenslandica</i> (Elix & Stevens) Elix
1984	<i>Bulbothrix haleana</i> Sérusiaux	-
1986	<i>Bulbothrix australiensis</i> Hale	-
1986	<i>Bulbothrix lopezii</i> Hale	-
1986	<i>Bulbothrix oliveirae</i> Fletcher	-
1992	<i>Bulbothrix leprieurii</i> Aubel	-
1993	<i>Bulbothrix microscopica</i> Elix	-
1993	<i>Bulbothrix linteolocarpa</i> Marcelli	-
1993	<i>Bulbothrix subklementii</i> Marcelli	-
1995	<i>Bulbothrix lordhowensis</i> Elix	-
1995	<i>Bulbothrix amazonensis</i> Marcano, Galiz & Morales	-
1996	<i>Bulbothricella amazonensis</i> (Marcano, Galiz & Morales) Marcano, Galiz, Moralez & Mohali	≡ <i>B. amazonensis</i> Marcano, Galiz & Morales
1997	<i>Bulbothrix tuskiformis</i> Elix	<i>Hypotrachyna tuskiformis</i> (Elix) Benatti & Marcelli

1999	<i>Bulbothrix sipmanii</i> Aptroot & Aubel	-
2000	<i>Bulbothrix yunnana</i> Wang, Chen & Elix	<i>Parmotrema yunnanum</i> (Wang, Chen & Elix) Marcelli & Benatti
2000	<i>Bulbothrix pinguicida</i> Louwhoff & Elix	<i>Parmelinopsis pinguicidum</i> (Louwhoff & Elix) Marcelli & Benatti
2002	<i>Bulbothrix cinerea</i> Marcelli & Kalb	-
2008	<i>Bulbothrix viatica</i> Spielmann & Marcelli	-
2008	<i>Bulbothrix megapotamica</i> Canêz & Marcelli	≡ <i>Bulbothrix viatica</i> Spielmann & Marcelli
2008	<i>Bulbothrix cassa</i> Jungbluth, Marcelli & Elix	-
2008	<i>Bulbothrix lacinulata</i> Marcelli, Jungbluth & Elix	≡ <i>Bulbothrix pseudocoronata</i> (Gyeln.) Benatti & Marcelli
2008	<i>Bulbothrix lobarica</i> Jungbluth, Marcelli & Elix	≡ <i>Bulbothrix subdissecta</i> (Nyl.) Hale
2008	<i>Bulbothrix regnelliana</i> Jungbluth, Marcelli & Elix	-
2008	<i>Bulbothrix vainioi</i> Jungbluth, Marcelli & Elix	≡ <i>Bulbothrix meizospora</i> (Nyl.) Hale
2011	<i>Bulbothrix caribensis</i> Marcelli & Benatti	-
2011	<i>Bulbothrix lyngei</i> Benatti & Marcelli	-
2012	<i>Bulbothrix laeviuscula</i> (Räsänen) Benatti & Marcelli	-
2012	<i>Bulbothrix subscortea</i> (Asahina) Marcelli & Benatti	-
2012	<i>Bulbothrix pseudocoronata</i> (Gyeln.) Benatti & Marcelli	
2012	<i>Bulbothrix pseudofungicola</i> Benatti & Marcelli	-
2012	<i>Bulbothrix silicisrea</i> Marcelli & Benatti	-
2013	<i>Bulbothrix bulbillosa</i> Benatti, Spielmann & Bungartz	-

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## Studies in lichens and lichenicolous fungi – No. 19: Further notes on species from the Coastal Plain of southeastern North America

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**ABSTRACT.** – Geographically disjunct and ecologically unusual populations of *Cladonia apodocarpa* from hardwood swamps are reported from southeastern North Carolina, and assignment to that species is confirmed with analyses of nrITS sequence data. The separation of *Lecanora cinereofusca* var. *cinereofusca* and *L. cinereofusca* var. *appalachensis* is discussed in the light of analyses of mtSSU and nrITS sequence data. *Lecanora cinereofusca* var. *appalachensis* is considered to merit recognition at the species level, for which the name *L. saxigena* Lendemer & R.C. Harris (*nomen novum pro L. appalachensis* (Brodo) non *L. appalachensis* Lendemer & R.C. Harris) is introduced. *Phlyctis ludoviciensis* is formally placed in synonymy with *P. boliviensis*. *Phlyctis willeyi* is shown to belong to the genus *Leucodecton* and the new combination *L. willeyi* (Tuck.) R.C. Harris is proposed. *Piccolia nannaria* is hypothesized to be a parasite on *Pyrrhospora varians* and is shown to be more widespread in the Coastal Plain than previously thought. *Schismatomma rappii* is revised, illustrated, and shown to be widespread in the Coastal Plain of southeastern North America. *Tylophoron hibernicum* is confirmed to be the correct name for all North American records of *T. protrudens*.

**KEYWORDS.** – Sandhills, maritime forest, barrier island, Mid-Atlantic, taxonomy, floristics.

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### INTRODUCTION

In 2012 we initiated an inventory of lichen biodiversity in the Mid-Atlantic Coastal Plain (MACP) with support from the U.S. National Science Foundation. The purpose of this inventory was to document and describe lichen biodiversity, and its patterns, in a little-studied region of North America whose remaining natural habitats are imperiled by anthropogenic forces including climate change (Auch 2000, Griffith et al. 2003, Lendemer & Allen 2013, Ricketts et al. 1999). Our work has led to the discovery of many species new to science, as well as large numbers of disjuncts and previously overlooked rare species (Lendemer 2013; Lendemer & Harris in press; Lendemer & Harris 2014a, b). Concurrently it has fundamentally reshaped our understanding of biogeographic patterns in the Coastal Plain, with respect to both the northern and southern distributional limits of taxa (see examples in Lendemer & Harris 2014b). During the course of this work we have also encountered many cases where newly collected material has prompted us to reexamine our understanding of recognized species, their distributions, and ecologies. Here we present a series of notes that fall into the latter category. We hope that these notes will be of use for those working in the region, as well as towards maintaining the Checklist of North American Lichens (Esslinger 2014).

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## MATERIALS AND METHODS

### *Fieldwork and herbarium vouchers*

This study is based largely upon the fieldwork conducted by the authors, together with their colleagues at The New York Botanical Garden, throughout the Mid-Atlantic Coastal Plain between 2012 and 2014. This includes >14,000 vouchers specimens deposited at The New York Botanical Garden (NY). These data were complemented by reference material already available at NY, and supplemented by a loan from H.

### *Morphological and chemical study*

The morphology of specimens was examined following the techniques of microscopy outlined by Lendemer (2011a). Chemistry was studied with standard spot test reagents (K, C, P and UV) following Brodo et al. (2001) and with Thin Layer Chromatography using Solvents A or C and the Peanut Butter Jar method outlined by Lendemer (2011a). Micrographs were captured following the methods outlined by Lendemer (2011a).

### *DNA extraction, amplification, and sequence generation*

Subsamples used for DNA extraction were those used in TLC analyses above such that the chemistry and identification of the vouchers had been confirmed. DNA extraction, PCR amplification, and sequence assembly followed the methods of Hodkinson and Lendemer (2012).

### *Molecular dataset assembly and taxon sampling*

Three molecular datasets were assembled for this study: 1) a dataset of nrITS sequences of *Cladonia* to confirm the identity of newly discovered populations of *C. apodocarpa*, 2) a dataset of mtSSU sequences to examine the position and monophyly of *Lecanora cinereofusca*, and 3) a dataset of nrITS sequences to examine the differences between *L. cinereofusca* var. *cinereofusca* and *L. cinereofusca* var. *appalachensis*.

For the first dataset (nrITS of *Cladonia*), all available nrITS sequences of *C. apodocarpa*, *C. petrophila* and *C. stipitata* were downloaded from GenBank. The taxon sampling was based on the MegaBlast similarity of the newly generated sequences to *C. apodocarpa*, and on the phylogeny of apodetiate *Cladonia* species published by Lendemer and Hodkinson (2009). The sequences were assembled into an alignment in Mesquite 2.0 (Maddison & Maddison 2009) and aligned manually. Ambiguously aligned and terminal regions were defined as part of an exclusion set.

The second dataset (mtSSU of *Lecanora*) was constructed to examine the relationships and placement of *Lecanora cinereofusca* within the Lecanoraceae. Taxon sampling within Lecanoraceae and selection of *Stereocaulon* as an outgroup was based on Miadlikowska et al. (2006). For this dataset four new sequences of *L. cinereofusca* var. *cinereofusca* and three of *L. cinereofusca* var. *appalachensis* were generated (see table 1 for voucher data and GenBank accession numbers). The following sequences were downloaded from GenBank: 1) all mtSSU sequences tagged with “*Lecanora*” returned from an NCBI Nucleotide search on 22 April 2014, 2) all mtSSU sequences tagged with “*Pyrrhospora*” returned from an NCBI Nucleotide search on 22 April 2014, 3) all mtSSU sequences tagged with “*Stereocaulon*” returned from an NCBI Nucleotide search on 22 April 2014. The sequences were assembled into an alignment in Mesquite and the following were pruned: 1) all sequences identified as taxa not belonging to the genus *Lecanora* (i.e., taxa tagged with the identifier “*Lecanora*” but actually belonging to other taxonomic groups), 2) all sequences not belonging to *Pyrrhospora* s. str. (i.e., those belonging to *Ramboldia* following Kalb et al. (2008)), 3) all sequences identified only to genus, or with an indication of hesitation (i.e., “aff” or “cf”). The dataset was then subjected to a multiple alignment using the MAFFT online interface, and subsequently adjusted manually in Mesquite. During the process of manual alignment the AY464085 was pruned because more than half of the mtSSU region was missing. Terminal regions and ambiguously aligned regions were defined as part of an exclusion set.

The third dataset (nrITS of *Lecanora*) comprised six newly generated sequences of *Lecanora cinereofusca* var. *cinereofusca* and *L. cinereofusca* var. *appalachensis* (three each). No additional sequences of this taxon were available in GenBank, and no sequences were downloaded for use as an outgroup because the *L. cinereofusca* was shown to be well-supported and monophyletic in analyses of the mtSSU dataset (see below) and because of overall poor resolution of relationships within the Lecanoraceae. The terminal ends of the alignment were defined as part of an exclusion set, but no ambiguously aligned regions were present.

Taxon	GenBank Accession			Voucher	Herbarium	Locality
	mtSSU	nrITS	Isolate			
<i>L. cinereofusca</i>	KP224462		NY1458	<i>Lendemmer 30827</i>	NY-1598083	U.S.A., North Carolina, Gates Co.
<i>L. cinereofusca</i>	KP224463		NY1460	<i>Lendemmer 27805</i>	NY-1222384	Canada, New Brunswick, Charlotte Co.
<i>L. cinereofusca</i>		KP224469	NY1457	<i>Lendemmer 30986</i>	NY-1597992	U.S.A., North Carolina, Gates Co.
<i>L. cinereofusca</i>	KP224465	KP224470	NY1521	<i>Lendemmer 34415</i>	NY-1772619	U.S.A., North Carolina, Dare Co.
<i>L. cinereofusca</i>	KP224464	KP224471	NY1520	<i>Lendemmer 35007</i>	NY-1808085	U.S.A., North Carolina, Dare Co.
<i>L. saxigena</i>	KP224460	KP224467	NY1461	<i>Lendemmer 25832</i>	NY-1217772	U.S.A., Arkansas, Madison Co.
<i>L. saxigena</i>	KP224459	KP224466	NY1445	<i>Lendemmer 32825</i>	NY-1684429	U.S.A., North Carolina, Swain Co.
<i>L. saxigena</i>	KP224461	KP224468	NY1447	<i>Lendemmer 33186</i>	NY-1684507	U.S.A., North Carolina, Swain Co.

Table 1. GenBank accession numbers and associated voucher information for newly generated sequences of *Lecanora cinereofusca* used in this study.

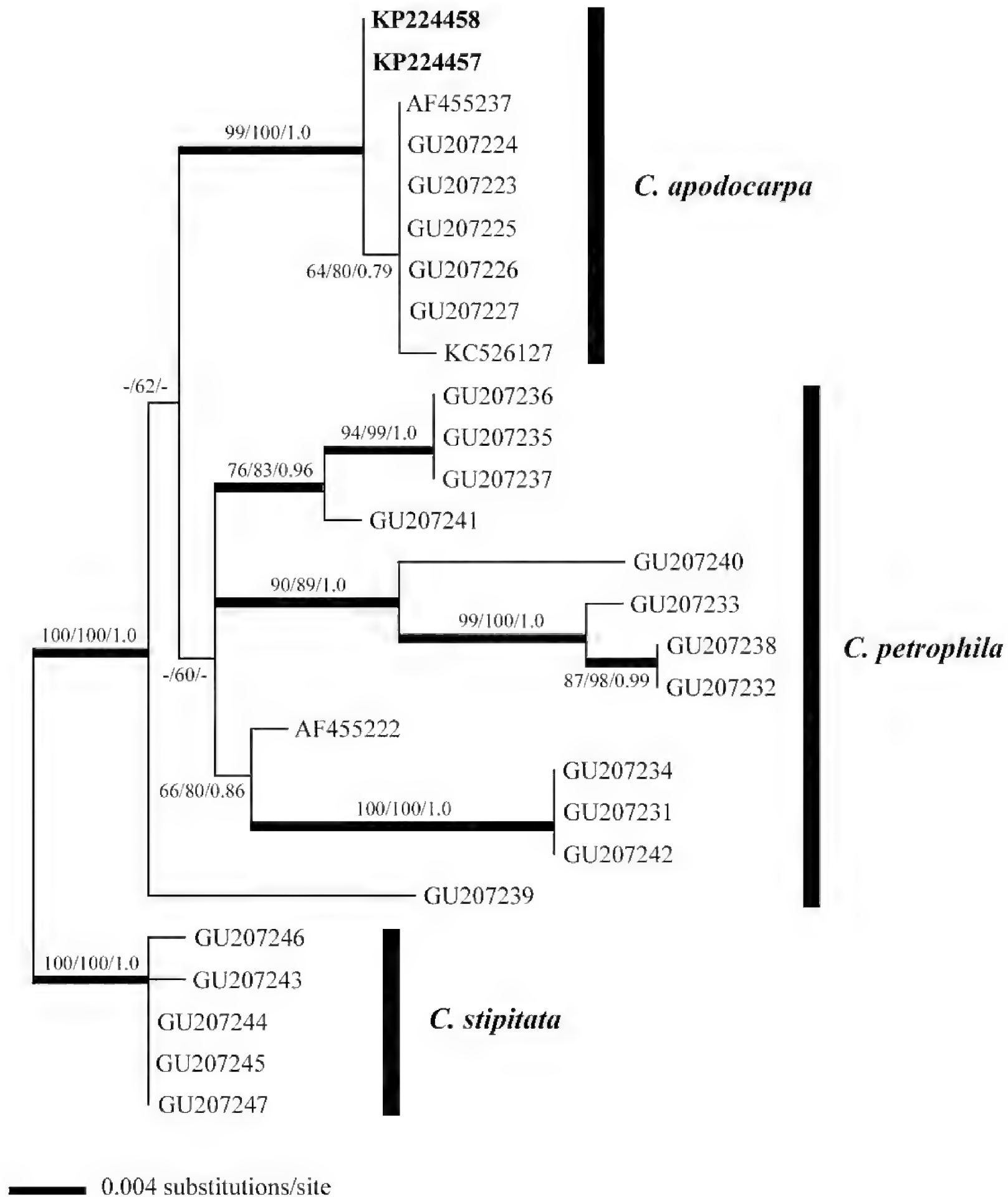
#### Molecular phylogenetic analyses

The first two datasets (nrITS of *Cladonia* and mtSSU of *Lecanora*) were prepared for maximum likelihood (ML) analysis using Mesquite by manually deleting the excluded regions, transforming the gaps (-) to missing (?), and transforming uncertainties/polymorphisms to missing (?). They were then exported as PHYLLIP formatted files, and rapid ML topology searches and bootstrap analyses with 500 replicates were performed using the model GTRGAMMA implemented in RAxML 7.2.6 (Windows executable, Stamatakis 2006). The results of the ML analyses were visualized in FigTree 1.3.1 (Rambaut 2009).

NEXUS formatted files of the same two datasets were then analyzed with Bayesian Inference (BI) using MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001). Before conducting the BI analyses, MrModeltest 2.3 (Nylander 2004) was used to select an appropriate model of nucleotide substitution. Using the Akaike Information Criterion (AIC; Akaike 1973) K80 was selected for the nrITS dataset and HKY+I+G was selected for the mtSSU dataset. A MrBayes block was produced for each dataset and the model settings from MrModelTest were pasted directly into the MrBayes block. For both sets of BI analyses, the Markov chain Monte Carlo parameters consisted of 10,000,000 generations, with four chains, and a tree sampled every 100 generations. The first 10,000 trees were discarded as burn-in and the results were summarized as a 50% majority rule consensus tree. The results were, again, visualized in FigTree.

The nrITS dataset for *Cladonia* was then also subjected to maximum parsimony analyses (MP). These were conducted using PAUP\* 4.0b10 (Swofford 1998) on a version of the dataset with ambiguously aligned regions and constant sites excluded. An initial search was made with 1,000 random-addition-sequence (RAS) replicates and tree bisection reconnection (TBR) branch swapping. The MULTREES option was in effect and zero-length branches were collapsed. All equally most parsimonious trees were saved with branch lengths. In this analysis the best tree island was hit in 100% of the replicates, and two equally most parsimonious trees were recovered (both equally most parsimonious trees were topologically equivalent). Branch support was estimated with bootstrap analyses by performing 1,000 bootstrap replicates with five RAS per bootstrap replicate, with all other settings as above. The results of these analyses were visualized in PAUP and exported as PDF files.

The datasets used in the above analyses are available in Dryad as doi:10.5061/dryad.8g55g and the GenBank accession numbers are listed with associated voucher data in the relevant sections below.



**Figure 1,** Phylogeny of *Cladonia apodocarpa* and its relatives, inferred from nrITS sequence data and displayed as the most likely tree with *C. stipitata* selected as the outgroup based on Lendemer and Hodkinson (2009). Support values are displayed in the following format: MP-BP/ML-BP/B-PP. Thickened branches are those that were recovered with MP-BP and ML-BP support  $\geq 70\%$  and B-PP  $\geq 0.95$ . The two newly generated sequences are marked by bold type face.

## NOTES

### I – A RANGE EXTENSION FOR *CLADONIA APODOCARPA* CONFIRMED WITH MOLECULAR DATA

*Cladonia apodocarpa* Robbins, Rhodora 27: 211. 1926. TYPE: U.S.A. MASSACHUSETTS. PLYMOUTH CO.: Wareham, 1924, C.A. Robbins s.n. (FH[n.v.], lectotype (designated by Ahti (1993))).

NOTES. – *Cladonia apodocarpa* is a distinctive species with large, strap-shaped primary squamules that produces atranorin and fumarprotocetraric acid (Lendemer & Hodkinson 2009). It is widely distributed on soil and humus in early succession or persistently open habitats throughout much of eastern North America, although to date it has not been reported from the Coastal Plain south of northeastern North Carolina (Brodo et al. 2001, Lendemer & Hodkinson 2009). This distribution is similar to that of other macrolichens such as *Parmotrema hypotropum* (Nyl.) Hale and *Punctelia caseana* Lendemer & B.P. Hodk. (Brodo et al. 2001, Culberson & Culberson 1973, Lendemer & Hodkinson 2010).

While collecting in hardwood swamp forests in southeastern North Carolina as part of our inventory of the MACP, we were surprised to find several populations of a *Cladonia* with large squamules that resembled *C. apodocarpa*. The populations were all found growing on the bark of mature hardwood (*Acer*, *Nyssa*) or cypress (*Taxodium distichum*) trees, just above the high water line, below which there were no lichens on the trees. Considering the ecology of these populations, and the fact that they occurred well outside the known distribution of *C. apodocarpa*, we initially assumed that they must represent an unusual tropical taxon with which we were unfamiliar. TLC of the specimens however, revealed the presence of atranorin and fumarprotocetraric acid, and thus suggested that the specimens belonged to *C. apodocarpa*.

In order to confirm the identity of the newly discovered material, we generated nrITS sequences from two specimens and placed them in a dataset comprised of sequences of *Cladonia apodocarpa*, *C. petrophila* and *C. stipitata*, which were shown to form a monophyletic group by Lendemer and Hodkinson (2009). The results of these analyses are presented in figure 1 where the newly generated sequences were resolved in a well-supported clade (MP/ML/BI: 99/100/1.0) together with the reference sequences of *C. apodocarpa*. The results of these analyses are largely congruent with those presented by Lendemer and Hodkinson (2009) which were based on a dataset with broader taxon sampling within *Cladonia*. A notable difference is that *C. petrophila* was recovered as monophyletic in these analysis, albeit with low support (only MP was  $\geq 50$ : 60), whereas the relationship between *C. petrophila* and *C. apodocarpa* was not resolved by Lendemer and Hodkinson (2009).

The populations of *Cladonia apodocarpa* reported here expand the known distribution of that species well into the Coastal Plain of North Carolina, and also expand the known ecological amplitude of the species. It is worth noting that despite extensive fieldwork in the region where *C. apodocarpa* has been documented previously, we have neither observed corticolous populations nor populations occurring in swamps or wetlands.

*Specimens examined.* – U.S.A. NORTH CAROLINA. COLUMBUS CO.: Columbus County Game Land, NE of Big Creek and Bella Coola Rd., 18.xi.2013, on large *Nyssa*, J.C. Lendemer et al. 39283 (NY [DNA isolate 2283; GenBank Accession No. KP224457]), J.C. Lendemer et al. 39286 (NY [DNA isolate 2284; GenBank Accession No. KP224458]).

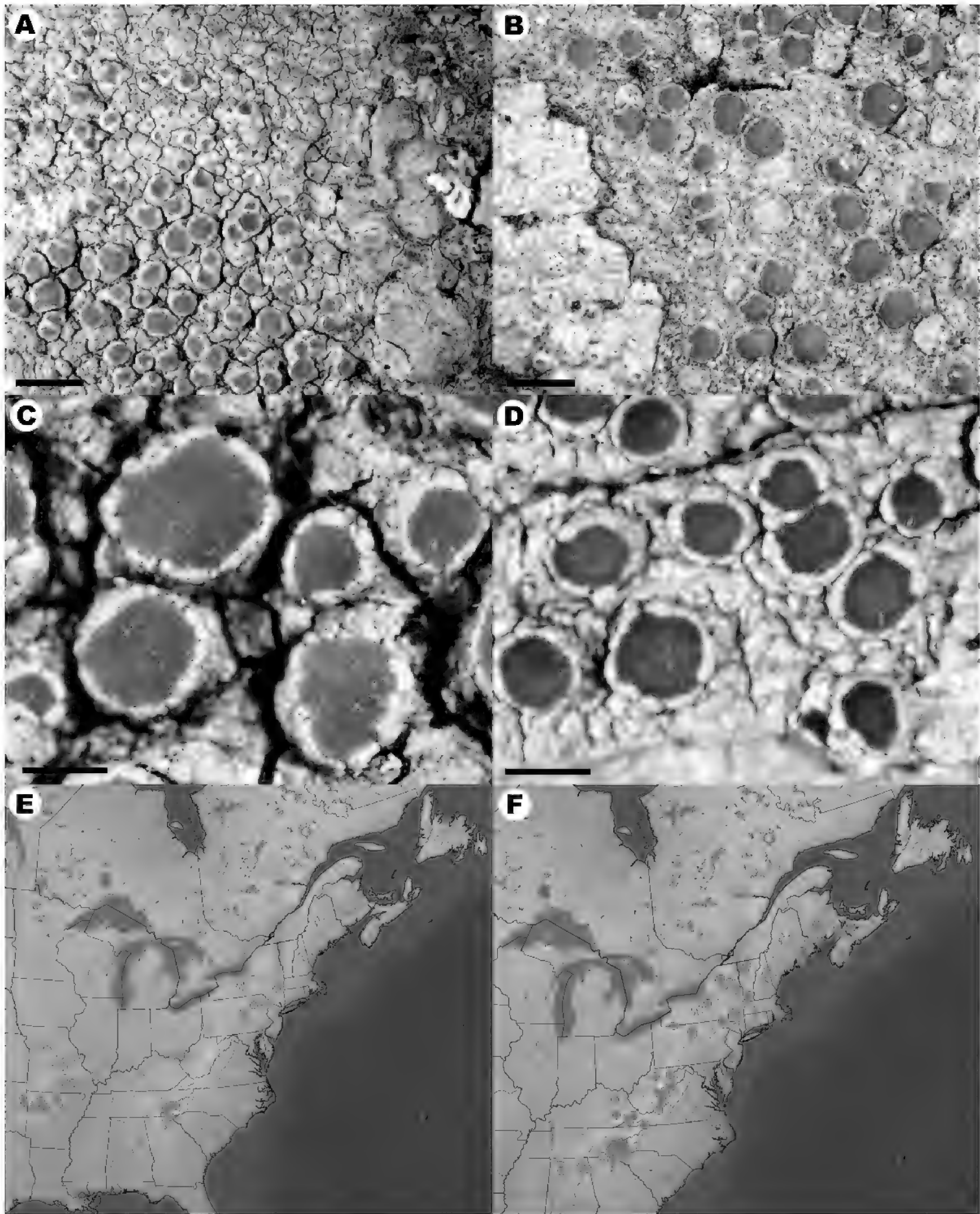
### II – *LECANORA CINEREOFUSCA* VAR. *APPALACHENSIS* MERITS RECOGNITION AT THE SPECIES LEVEL

*Lecanora saxigena* Lendemer & R.C. Harris, nom. nov.

Mycobank #810928.

≡ *Lecanora cinereofusca* var. *appalachensis* Brodo, Beih. Nov. Hedwigia 79: 116. 1984. (non *L. appalachensis* Lendemer & R.C. Harris, Mem. N.Y. Bot. Gard. 104: 29. 2013). TYPE: U.S.A. ARKANSAS. NEWTON CO.: Lost Valley State Park, 22 mi SW of Harrison, 11.viii.1979, on sandstone boulder, I.M. Brodo 23512 (CANL[n.v.], holotype).





**Figure 2**, comparison of *Lecanora cinereofusca* (right) and *L. saxigena* (left). A, gross morphology of *L. saxigena* (Lendemer 25832). B, gross morphology of *L. cinereofusca* (Lendemer 23455). C, detail of apothecia of *L. saxigena* (Lendemer 235832). D, detail of apothecia of *L. cinereofusca* (Buck 56298). E, known geographic distribution of *L. saxigena* based on specimens examined for this study. F, known geographic distribution of *L. cinereofusca* based on specimens examined for this study. Scales = 2.0 mm in A and B, 0.5 mm in C and D.

NOTES. – *Lecanora cinereofusca* H. Magn. is a common species that is widespread in temperate North America, being common in the Pacific Northwest as well as the Appalachian-Great Lakes Region. Its distribution also extends into subtropical portions of the Mid-Atlantic Coastal Plain (figure 2F). It can be recognized in the field by its distinctive apothecia that are relatively large, often semi-immersed in the thallus, and typically have beaded margins (figures 2B and D; Brodo et al. 2001). The identification can be confirmed by the presence of pannarin in the epihymenium (P+ orange-red), and ascospores that are  $10\text{--}14 \times 7\text{--}9 \mu\text{m}$  in size (Brodo 1984).

When Brodo (1984) monographed the *Lecanora subfusca* group in North America he described *L. cinereofusca* var. *appalachensis* to accommodate a taxon that was morphologically similar to *L. cinereofusca*, but differed ecologically in occurring on non-calcareous rocks rather than bark and chemically in producing roccellic acid but lacking placodiolic acid. While *L. cinereofusca* is widespread in northern-temperate North America, *Lecanora cinereofusca* var. *appalachensis* is restricted to the Appalachian Mountains and Ozark Highlands of eastern North America (figure 2E).

Considering the differences in biogeography, ecology, and chemistry between *Lecanora cinereofusca* and *L. cinereofusca* var. *appalachensis*, we have long speculated that the latter merits recognition at the species level. This hypothesis was developed during our inventory of the Ozark Ecoregion where both taxa are common and reinforced during inventories of Pennsylvania and the Great Smoky Mountains in the Appalachian Mountains, where both species also occur. Recognizing that we had access to ample fresh material, we were prompted to examine the problem with molecular data as part of our inventory of the MACP.

The results of our analyses of mtSSU sequences of *Lecanora cinereofusca* (four sequences) and *L. cinereofusca* var. *appalachensis* (three sequences) are presented in figure 3. These analyses recovered the two entities as a strongly supported monophyletic group (ML/BI: 100/1.0) that was strongly supported as a member of the Lecanoraceae (ML/BI: 100/1.0) but whose relationship to *Lecanora*, *Lecidella* and *Pyrrhospora* was not resolved. The mtSSU sequences of *L. cinereofusca* and *L. cinereofusca* var. *appalachensis* were >99% identical, although comparing the two sets of sequences there were two positions where there appear to be consistent differences between the two taxa (var. *cinereofusca* has thymine at position 636 and adenine at position 674 whereas var. *appalachensis* had cytosine and guanine at those same positions).

Since the taxa were recovered as a strongly supported monophyletic group in our mtSSU analyses, we then compared nrITS sequences of the two taxa. Data from the nrITS region are often useful in resolving species boundaries in lichens (Amtoft et al. 2008; Gaya et al. 2011; Lendemer 2011b, 2012; Lendemer & Harris 2014a; Lumbsch et al. 2008; McDonald et al. 2003; Otálora et al. 2008; Vondrák et al. 2010) and the region has been designated as the official “barcoding” region for fungi (Schoch et al. 2012). As such, we generated three nrITS sequences of each taxon and a Jukes-Cantor distance matrix comparing the sets of sequences (table 2). The average distance within each taxon was <1% (0.1+/-0.1 for var. *appalachensis* and 0.9+/-1.0 for var. *cinereofusca*) while the average distance between the two taxa was 7.2+/-0.2%. The distances observed within and between the taxa correspond well to that observed in other studies of sister lichen species (e.g., Lendemer & Harris 2014a) and to those accepted for inter- and intra-species variation within lichen-forming ascomycetes (Nilsson et al. 2008).

To summarize, *Lecanora cinereofusca* var. *cinereofusca* and *L. cinereofusca* var. *appalachensis* are two taxa that differ in ecology and chemistry. The two taxa also differ in geographic distribution, although the former is entirely sympatric with the latter (i.e., var. *cinereofusca* is widespread throughout North America whereas var. *appalachensis* is restricted to several mountainous areas of eastern North America). The two taxa form a strongly supported, monophyletic group and have nrITS sequences that are 7.2+/-0.2% divergent (i.e., a degree of divergence that is to be expected between, rather than within, species). Based on these correlated characters we assert that *L. cinereofusca* var. *appalachensis* merits recognition at the species level, and propose the necessary nomenclatural change here. The epithet “appalachensis” is however, preoccupied at the species level within *Lecanora* by *L. appalachensis* Lendemer & R.C. Harris (see Lendemer et al. 2013). As such we provide a new name for the taxon, *L. saxigena* (“arising from rock”) that denotes the saxicolous habit of the species and the aspect of the apothecia, which appear to “arise” from the rock substrate.





*Specimens of Lecanora saxigena examined.* – **CANADA.** NEWFOUNDLAND AND LABRADOR: Newfoundland, Leading Tickle, 14.vi.1894, on sandstone, *A.C. Waghorne* 56 (NY). **U.S.A.** **ALABAMA.** CLAY CO.: Talladega National Forest, Cheaha Wilderness, 24.ix.1992, on schist, *R.C. Harris* 28377 (NY). MARION CO.: North Fork Creek of Buttahatchee River at US43, 27.ix.1992, on sandstone, *R.C. Harris* 28356 (NY). **ARKANSAS.** FRANKLIN CO.: Ozark National Forest, Shores Lake, 17.x.2005, on rock, *W.R. Buck* 49546 (NY). NEWTON CO.: Ozark National Forest, E of FSR1463, 2.6 mi N of AR21, 28.iii.2006, on rock, *J.C. Lendemer et al.* 6532 (NY). POPE CO.: Ozark National Forest, Cowan Hollow, 7.xi.2002, on rock, *R.C. Harris* 46913 (NY). STONE CO.: Cherokee Wildlife Management Area, 25.x.2001, on rock, *W.R. Buck* 40358 (NY). **GEORGIA.** UNION CO.: Chattahoochee National Forest, along Duncan Ridge Trail from Wildcat Gap to Coosa Bald, 6.x.1998, on rock, *W.R. Buck* 34870 (NY). **ILLINOIS.** JACKSON CO.: Shawnee National Forest, Pomona Natural Bridge, 15.x.1993, on sandstone, *R.C. Harris* 31276 (NY). **KENTUCKY.** NELSON CO.: Bernheim Arboretum and Research Forest, 23.x.2002, on siltstone, *D. Ladd* 23988 (NY). **MISSOURI.** DENT CO.: Montauk State Park, 3.xi.2004, on rock, *R.C. Harris* 50229 (NY). DOUGLAS CO.: Mark Twain National Forest, Dimcher Hollow, 18.iv.1997, on sandstone, *W.R. Buck* 32077 (NY). MARIES CO.: Spring Creek Gap Conservation Area and Spring Creek Gap Glades Natural Area, 4.xi.2002, on sandstone, *W.R. Buck* 42787 (NY). OREGON CO.: Mark Twain National Forest, McCormack Lake Recreation Area, 26.iv.1988, on rock, *R.C. Harris* 21695 (NY). **NEW YORK.** GREENE CO.: Catskill Mountains, Long Path from Malden Ave. in Palenville to above Kaaterskill Clove, 9.v.1993, on rock, *W.R. Buck* 23115 (NY). **NORTH CAROLINA.** CLAY CO.: Nantahala National Forest, stream bed/valley of Buck Creek, 10.xi.2007, on schist, *J.C. Lendemer et al.* 10452 (NY). SWAIN CO.: Great Smoky Mountains National Park, vicinity of High Rocks, 6.viii.2012, on rock, *J.C. Lendemer* 32825 & *E. Tripp* (NY). **OHIO.** GALLIA CO.: Wayne National Forest, above Symmes Creek, 19.v.2006, on sandstone, *J.C. Lendemer et al.* 7438 (NY). SCIOTO CO.: Shawnee State Forest, along Pond Lick Run N of FS1, 21.v.2006, on sandstone, *R.C. Harris* 52756 (NY). **OKLAHOMA.** ADAIR CO.: just NE of Stilwell City Lake, 1.xi.2000, on sandstone, *R.C. Harris* 44516 (NY). CHEROKEE CO.: J.T. Nickel Family Nature and Wildlife Preserve (J5 Ranch), 30.x.2000, on sandstone, *W.R. Buck* 38456 (NY). **PENNSYLVANIA.** LACKAWANNA CO.: State Game Lands No. 300, N end of Moosic Mountains, 3.vii.2008, on sandstone, *J.C. Lendemer* 12456 (NY). PIKE CO.: State Game Lands No. 209, terminus of Pond Eddy/Firetower Rd., 28.vii.2009, on sandstone, *J.C. Lendemer* 18655 (NY). UNION CO.: Bald Eagle State Forest, White Deer Creek Rd. 1 mi S of jct w/ SR1010, 19.x.2009, on sandstone, *J.C. Lendemer* 19833 (NY). WAYNE CO.: State Game Lands No. 57, ~5 mi W of Noxen, 19.vii.2008, on sandstone, *J.C. Lendemer* 13457 (NY). **TENNESSEE.** BLOUNT CO.: Great Smoky Mountains National Park, Abrams Creek, 30.vi.2010, on rock, *R.C. Harris* 56389 (NY). SEVIER CO.: Great Smoky Mountains National Park, Bullhead Trail, 0–5 mi from parking area on Cherokee Orchard Rd., 9.x.2011, on sandstone, *J.C. Lendemer et al.* 2150 (NY).

### III – *PHLYCTIS LUDOVICIENSIS* IS A SYNONYM OF *P. BOLIVIENSIS*

*Phlyctis boliviensis* Nyl., Ann. Sci. Nat. Bot., ser. 4, 11: 221. 1859. **TYPE: BOLIVIA:** without locality, ad corticem crotonis? (Cascarilla de la frontera), *Weddell s.n.* (H-NYL 22380!, holotype).

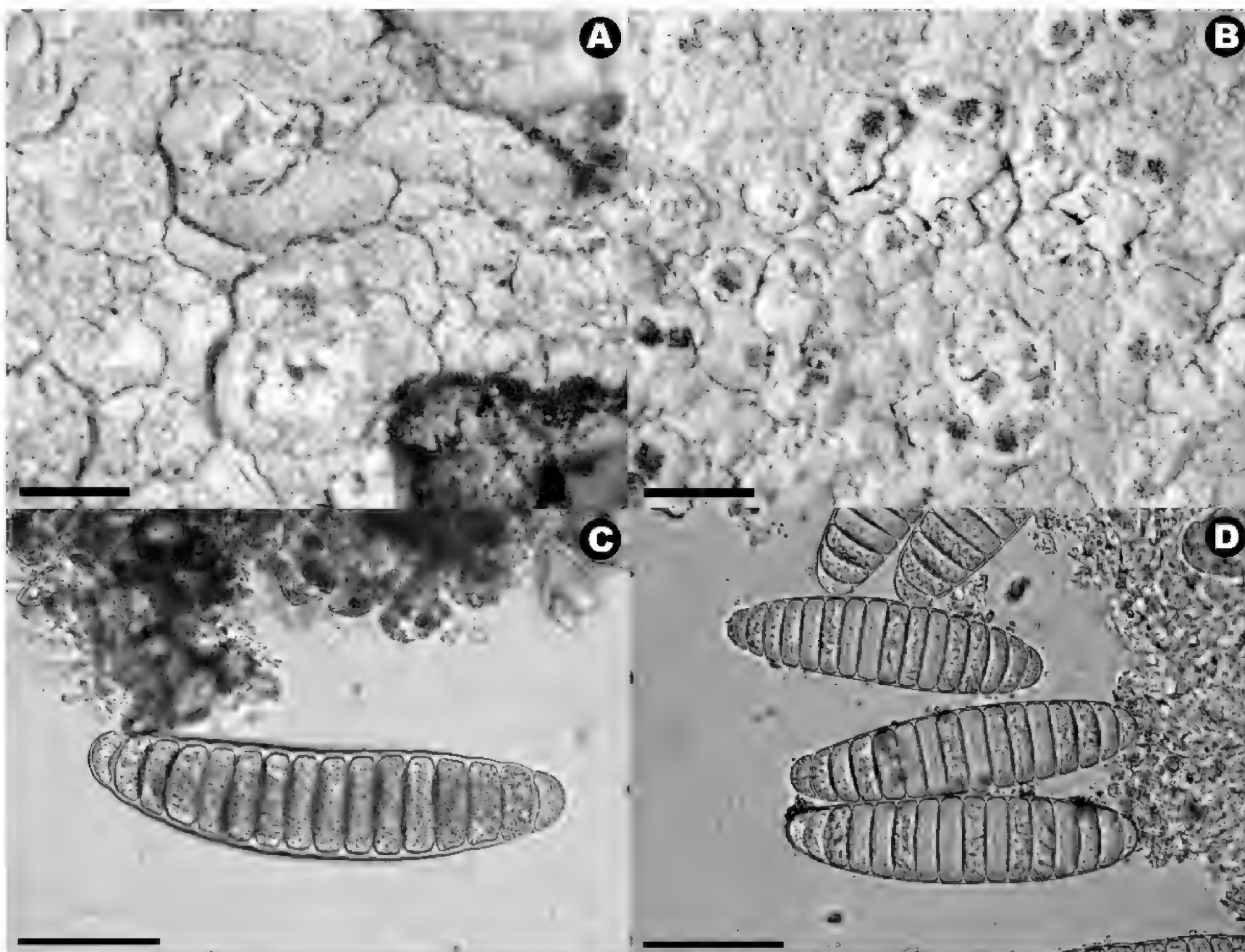
≡ *Phlyctidia boliviensis* [as *boliviensi*] (Nyl.) Müll. Arg., Flora 63: 287. 1880.

= Syn. nov. *Phlyctidia ludoviciensis* Müll. Arg., Hedwigia 34: 141. 1895 [19 June 1895]. **TYPE: U.S.A. LOUISIANA.** [ST. MARTIN PARISH]: St. Martinsville, 4.vi.1894, on *Planera aquatica*, *A.B. Langlois* 830 (G[n.v.], holotype; PH!, isotype).

≡ *Phlyctis ludoviciensis* (Müll. Arg.) Lendemer. Opuscula Philolichenum 2: 52. 2005.

NOMENCLATURAL NOTES. – Zahlbruckner (Cat. Lich. 5: 789. 1928) erroneously listed the protologue of *Phlyctidia ludoviciensis* as having been published on page 111 rather than on page 141. When describing *Phlyctidia ludoviciensis*, Müller cited as the type “Corticola in Planera aquatica prope Martinville in Louisiana s. Ludoviciana: Dr. Eckfeldt n. 830.” The reference to “Dr. Eckfeldt” as collector is an error that is due to that fact that when Eckfeldt sent material to correspondents he often omitted the name of the original collector (Lendemer & Hewitt 2002). The isotype at PH retains the original label from Langlois confirming that he was the collector and that he assigned the gathering number 830.





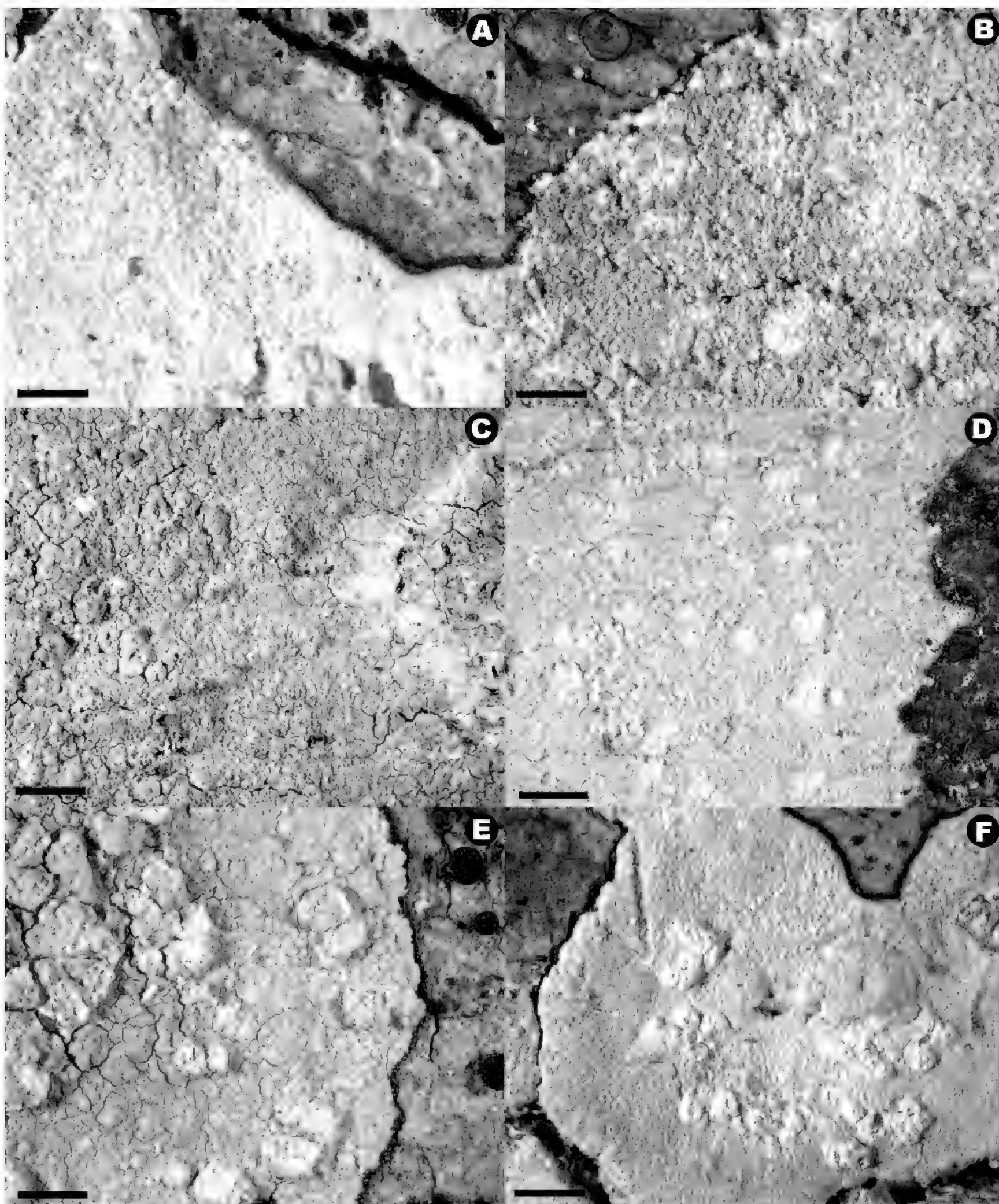
**Figure 4**, comparison of authentic material of *Phlyctis boliviensis* (left) and *P. ludoviciensis* (right). A, morphology thallus and apothecia in the holotype of *P. boliviensis* (H-NYL 22380). B, morphology of thallus and apothecia in authentic specimen of *P. ludoviciensis* (Langlois 1036, NY). C, ascospore from holotype of *P. boliviensis*. D, ascospores of *P. ludoviciensis* from the specimen illustrated in B. Scales = 0.5 mm in A and B, 50  $\mu$ m in C and D.

As an interesting bit of lichenological history, the specimen cited below (Langlois 1036, NY) is labeled “*Phlyctis ludoviciensis* Stitz. (nominavit Stizenberger)”. Stizenberger never published this combination, and in fact it was not validated until 2005. Nonetheless, we surmise that since Müller’s article appeared in June 1895, Stizenberger had seen it when he received material directly from Langlois collected in July 1895 but took Nylander’s view in not recognizing “spore genera”, i.e., *Phlyctidia*, and thus placed the species in *Phlyctis* and attributed the name to himself.

NOTES. – As part of a revisionary study of the genus *Phlyctis* (Wallr.) Flot. in eastern North America, study of the type of *Phlyctis boliviensis* and authentic material of *Phlyctidia ludoviciensis* revealed that they were identical in ascomatal type (figures 4A and B), ascospore size and septation (figures 4C and D), and in producing psoromic acid.

The species is very common in the southeastern United States and is, when fertile, easily recognized by the thick blue-gray thallus, *Phlyctis*-type ascomata (buried in the thallus and covered with thalline granules), large transversely 15-septate ascospores ( $120\text{--}200 \times 30\text{--}50 \mu\text{m}$ ), and presence of psoromic acid. However, it is often sterile with aborted ascomata or almost leprose and totally lacking ascomata. In such cases it must be recognized by the thallus morphology, green coccoid photobiont and the presence of psoromic acid. Considering the extreme variation in reproductive modes (figure 5) displayed in *P. boliviensis*, we speculate that it may be a species in the process of abandoning sexual reproduction. Unfortunately attempts to sequence material have not been successful.

It should be noted that the relationship between *Phlyctis boliviensis* and other members of the genus has been confused in the literature as a result of the erroneous statement by Lendemer (2005) that the



**Figure 5**, morphological variation observed in North American populations of *Phlyctis boliviensis*. A, entirely leprose thallus with coarse granules (*Lendemer 42935*). B, entirely leprose thallus with finer, fluffy granules (*Lendemer 36396*). C, continuous thallus with older portions breaking down into coarse granulose structures and poorly developed apothecia (*Lendemer 43035*). D, thin continuous thallus with poorly developed and sterile apothecia (*Lendemer 31203*). E, thicker continuous thallus with large, well developed apothecia (*Lendemer 30542*). F, thick continuous thallus with nearly corticate appearance and well developed apothecia (*Lendemer 39662*). All scales = 1.0 mm.

species had muriform ascospores. As clarified here, and as originally published in the protologue, the species has large transversely septate ascospores. Indeed, the presence of transversely septate ascospores is what prompted Müller to originally describe the species in the genus *Phlyctidia*. *Phlyctis monosperma* Joshi & Upreti (Joshi et al. 2012) also with psoromic acid and transversely septate ascospores has been described recently, and should be reevaluated as a possible synonym of *P. boliviensis*.

*Additional authentic specimen examined.* – **U.S.A. LOUISIANA.** ST. MARTIN PARISH: near St. Martinville, 17.vii. 1895, on *Carya aquatica*, A. B. Langlois 1036 (NY).

#### IV - *PHLYCTIS WILLEYI* BELONGS IN *LEUCODECTON*

*Leucodecton willeyi* (Nyl.) R. C. Harris, comb. nov.

Mycobank #810929.

FIGURE 6.

≡ *Phlyctis willeyi* Nyl., Lich. Japon. 106. 1890. TYPE: **U.S.A. TEXAS:** Brownsville, 1885, H.L. Higginson (H-NYL 22373!, holotype).

NOTES. – As another facet of the study of the genus *Phlyctis* (Wallr.) Flot. in eastern North America the type of *P. willeyi* was studied. The violet iodine reaction of the ascospores immediately excludes it from *Phlyctis* (ascospores I-) and suggests placement in the Graphidaceae. However, it does not fall neatly into any currently recognized genus. On the recommendation of Robert Lücking (pers. comm.) we are placing it in *Leucodecton*, a logical disposition as it shares a number of characters with *L. glaucescens* (Nyl.) Frisch. In both species the thallus has eroded areas, the ascomata are immersed and clustered, the exciple is poorly developed, and stictic acid agg. is present. *Phlyctis willeyi* differs notably however, in having hyaline ascospores whereas those of *L. glaucescens* are brown.

*Leucodecton willeyi* is known only from the type collection. It can be recognized by the slightly shiny, brownish (in the herbarium) thallus that is eroded and paler around and between the ascomata. The ascomata are aggregated in groups in eroded areas, breaking loose from bark, without an obvious exciple, lacking periphysoids, and with a weakly pruinose disk. Internally the paraphysis tips are not ornamented, not forming a distinct epihymenium, the asci monosporous with hyaline, muriform, I+ violet, 92–150 × 32–60 µm (*fide* Nylander) ascospores. Due to the small size of the type material only TLC was conducted, which revealed the presence of hypostictic acid together with the stictic acid aggregate. The spot test reactions for the species are probably K+ yellow and PD+ orangish, based on the chemistry detected by TLC, but we did not want to damage the specimen further by conducting spot tests. The thallus is definitively UV- however.

#### V – Revised ecology and distribution of *Piccolia nannaria*

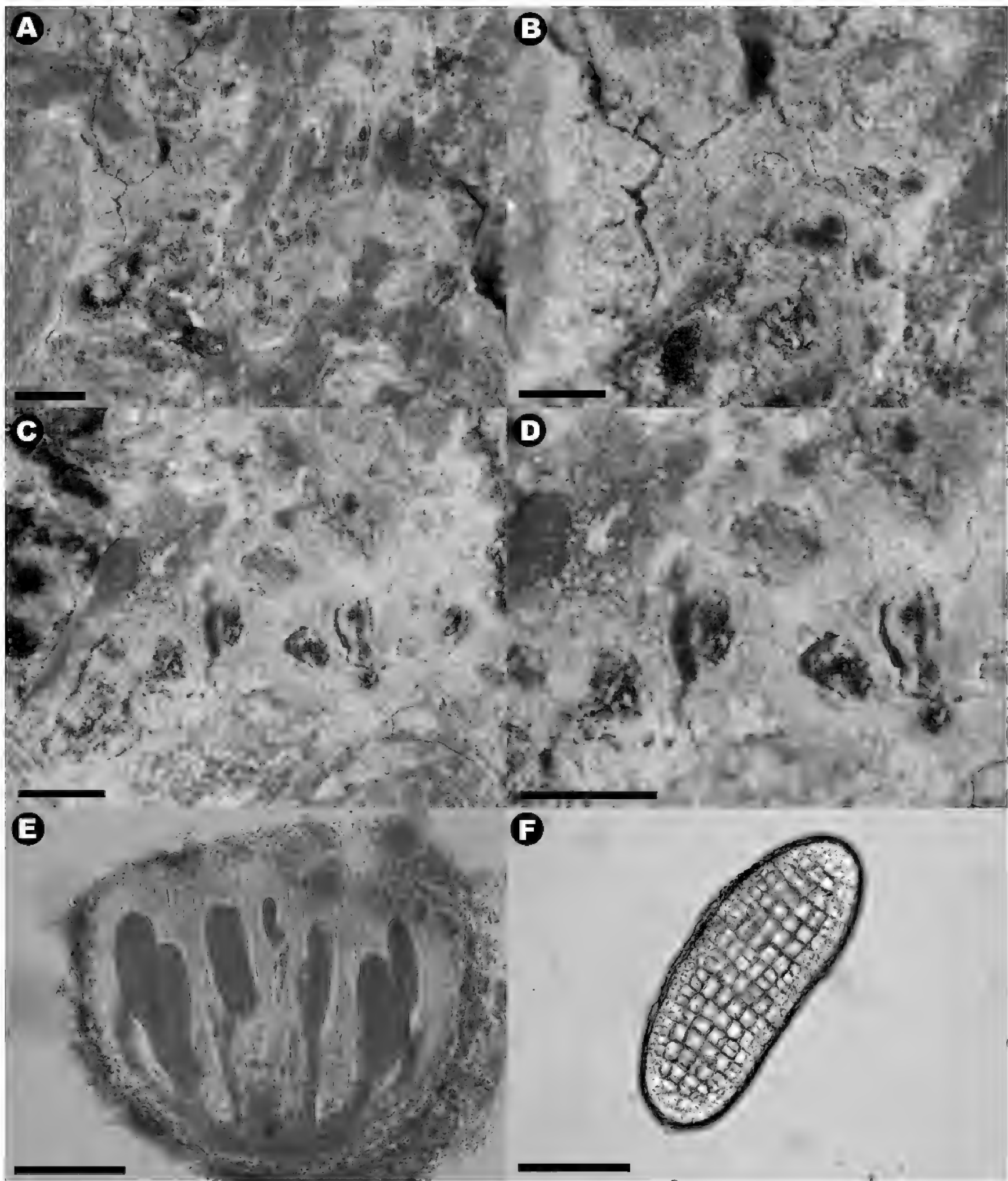
*Piccolia nannaria* (Tuck.) Lendemer & Beeching in Knudsen & Lendemer, Mycotaxon 101: 83.2007.

≡ *Heterothecium nannarium* Tuck., Gen. Lich., p. 176. 1872. TYPE: **U.S.A. TEXAS.** BLANCO CO.: on the Blanco, 1850, C. Wright s.n. (FH-TUCK!, lectotype designated by Knudsen & Lendemer (2007)).

≡ *Biatorrella nannaria* (Tuck.) Zahlbr., Cat. Lich. Univers. 5: 44. 1927.

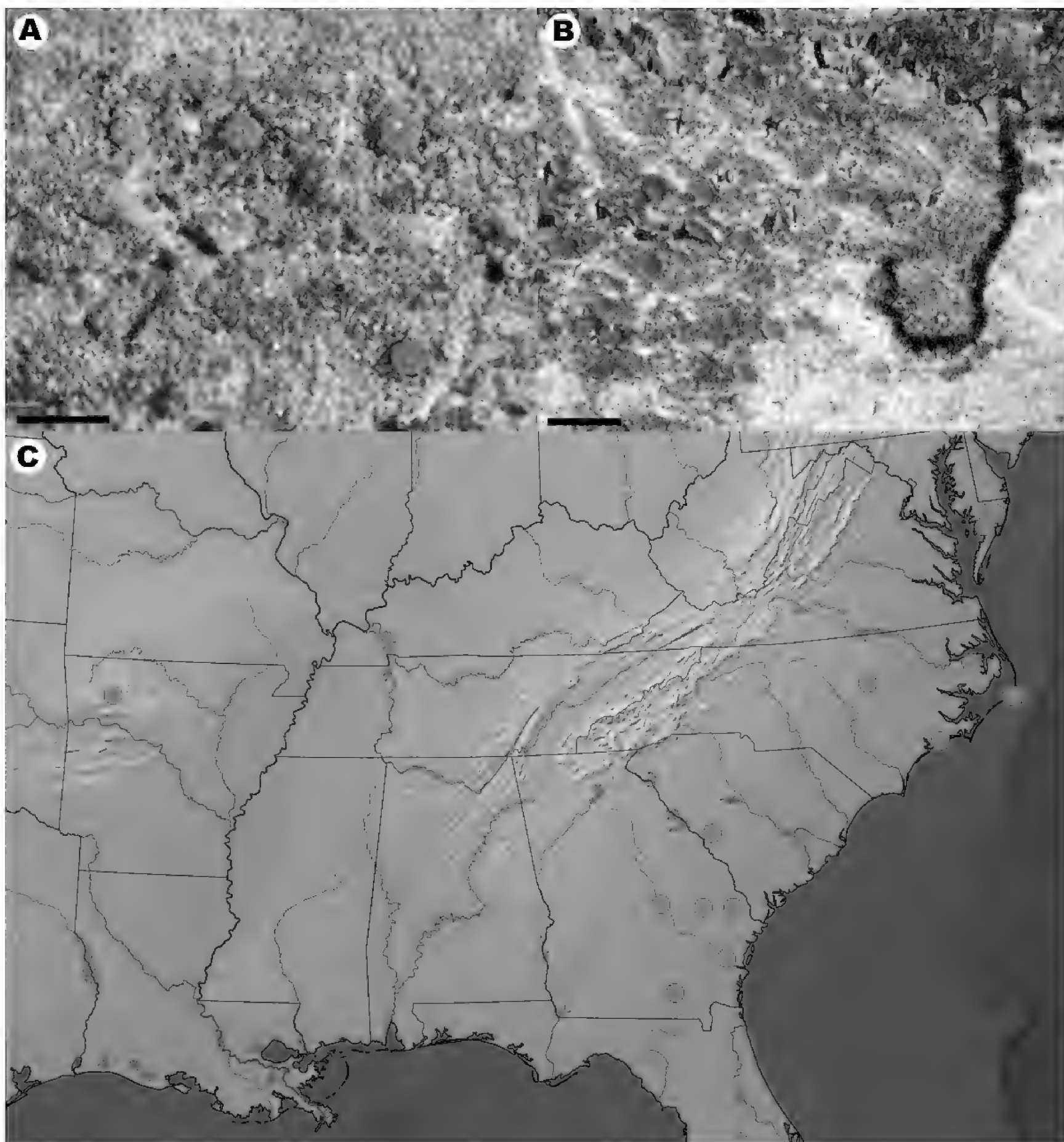
NOTES. – *Piccolia nannaria* is an inconspicuous crustose lichen with a granular, leprose yellow thallus, minute greenish to orange-yellow apothecia and polysporous asci containing many minute globose hyaline ascospores (figures 7A, 7B and 8). When we first encountered this species, we found it on the undersides or sheltered faces of hardwood branches and trunks in sandhill communities in the Coastal Plain from North Carolina south to Georgia (Knudsen & Lendemer 2007). During our inventory of the MACP, we found the species in similar habitats as far north as Maryland, extending its known range considerably (figure 7C).





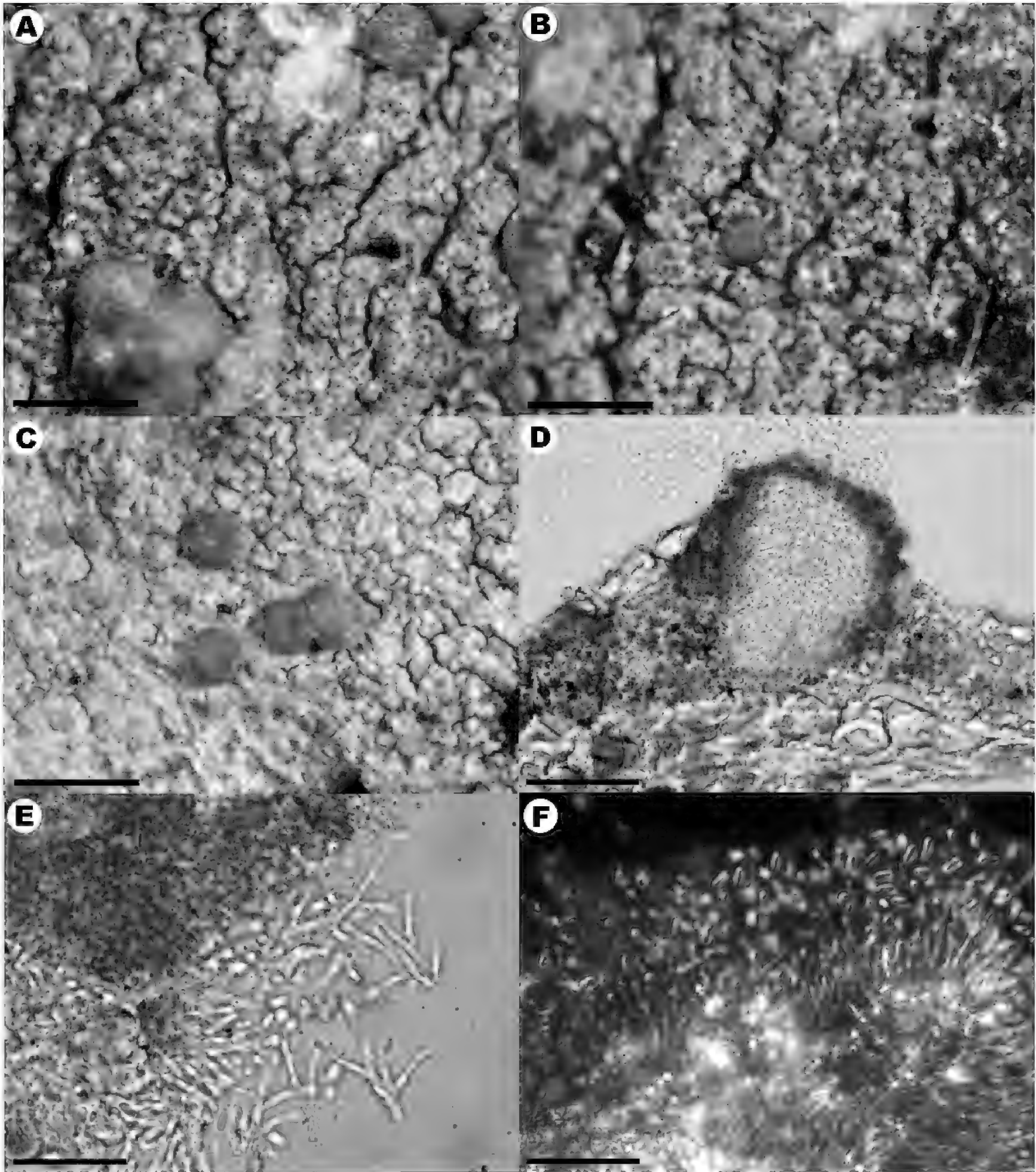
**Figure 6**, morphology of the holotype of *Phlyctis willeyi*. A, gross morphology of the thallus and ascomata. B-D, detail of the ascomata. E, transverse section through a hymenium mounted in cotton blue. F, ascospore mounted in water. Scales = 1.0 mm in A, 0.5 mm in B-D, 100  $\mu$ m in E, and 50  $\mu$ m in F.





**Figure 7**, habit and distribution of *Piccolia nannaria*. A, independent thallus and apothecia showing no signs of parasitism (*Lendemer* 38680). B, parasitic thallus with apothecia heavily infecting a thallus of *Pyrrhospora varians* with addition overgrowth onto adjacent thallus of *Pertusaria pustulata* (white thallus). C, known geographic distribution of *P. nannaria* based on specimens examined for this study. Scales = 0.2 mm in B, 0.5 mm in A.

We also encountered several populations, with abundant pycnidia and lacking apothecia, growing on canopy branches in hardwood swamps on the Delmarva Peninsula. Pycnidia and conidia have not previously been reported from this species and are illustrated here (figure 8). The morphology of these structures in *P. nannaria* is comparable to that of the type of the genus, *P. conspersa* (Ach.) Hafellner as illustrated by Hafellner (1995). Initially we suspected that the material represented an additional species of *Piccolia* because the thalli were found growing directly on the common crustose lichen *Pyrrhospora varians* (Ach.) R.C. Harris and appeared to be facultative or juvenile parasites. After recognizing the link with *Pyrrhospora varians*, we subsequently found fertile material (i.e., with apothecia) associated with the same host on hardwood trunks in relatively open swamp forests of the Dare Regional Biodiversity Hotspot



**Figure 8**, parasitic thalli of *Piccolia nannaria* producing only pycnidia and no apothecia. A-C, early stages of development of *P. nannaria* (small yellow pycnidia, yellow patches of thallus) morphing out of thalli of *Pyrrhospora varians* (green thallus and brown apothecia) (A and B from *Allen 853*, C from *Harris 58090*). D, transverse section of pycnidium of *P. nannaria* in water (*Harris 58090*). E, conidiophores and conidia of *P. nannaria* in water (*Harris 58090*). F, conidia in water viewed with DIC (*Harris 58090*). Scales = 0.5 mm in A-C, 50  $\mu$ m in D, 20  $\mu$ m in E and F.

in North Carolina. We were then prompted to reexamine our collections from the sandhills, and were surprised to find that in nearly all of the cases *Piccolia nannaria* was closely associated with *Pyrrhospora varians*, occasionally completely obscuring the thallus of the latter.

Whether *Piccolia nannaria* is truly parasitic requires further investigation. However, this clarification of its ecology aids considerably in explaining the disparate habitats in which it has been encountered, since *Pyrrhospora varians* is a common and widespread species. Additionally, it should aid others in searching for the species, because previously we would likely have assumed that a yellow granulose lichen overgrowing *Pyrrhospora varians* was simply a sterile or poorly developed *Candelariella*.

*Selected specimens examined.* – **U.S.A. ARKANSAS.** MADISON CO.: Kings River Falls Natural Area, 5.x.2010, on *Acer*, J.C. Lendemer et al. 25903 (NY). **GEORGIA.** CANDLER CO.: Fifteenmile Creek Preserve, 22.xii.2009, on *Quercus* branch, J.C. Lendemer et al. 21632 = *Lich. East. N. Amer. Exs. VII*: 376 (NY) WAYNE CO.: Sansaville Wildlife Management Area, 21.xii.2009, on *Ilex*, J.C. Lendemer et al. 21552 (NY). **MARYLAND.** WORCESTER CO.: Pocomoke State Forest, Pocomoke Swamp, 15.xi.2012, on *Pyrrhospora varians* on fallen branch, J.L. Allen et al. 853 (NY); Pocomoke State Forest, Hickory Point Swamp, 15.xi.2012, on *P. varians* on fallen branch, R.C. Harris 58090 (NY). **NORTH CAROLINA.** DARE CO.: Cape Hatteras National Seashore, NW of Frisco Campground and Ramp 49, 19.iii.2013, on *Quercus* branch, J.C. Lendemer 36188-A (NY). TYRRELL CO.: Pocosin Lakes National Wildlife Refuge, 0–0.4 mi N of Bodwell Rd., 2.5 mi W of jct w/ Newlands Rd., 23.iii.2012, on *Acer*, E. Tripp et al. 4218 (NY). **SOUTH CAROLINA.** AIKEN CO.: The Hitchcock Woods, just SW of city of Aiken, 14.iii.2010, on *Quercus* branch, B.P. Hodkinson 11434 (NY).

#### VI – REVISED DESCRIPTION AND DISTRIBUTION FOR *SCHISMATOMMA RAPPII*

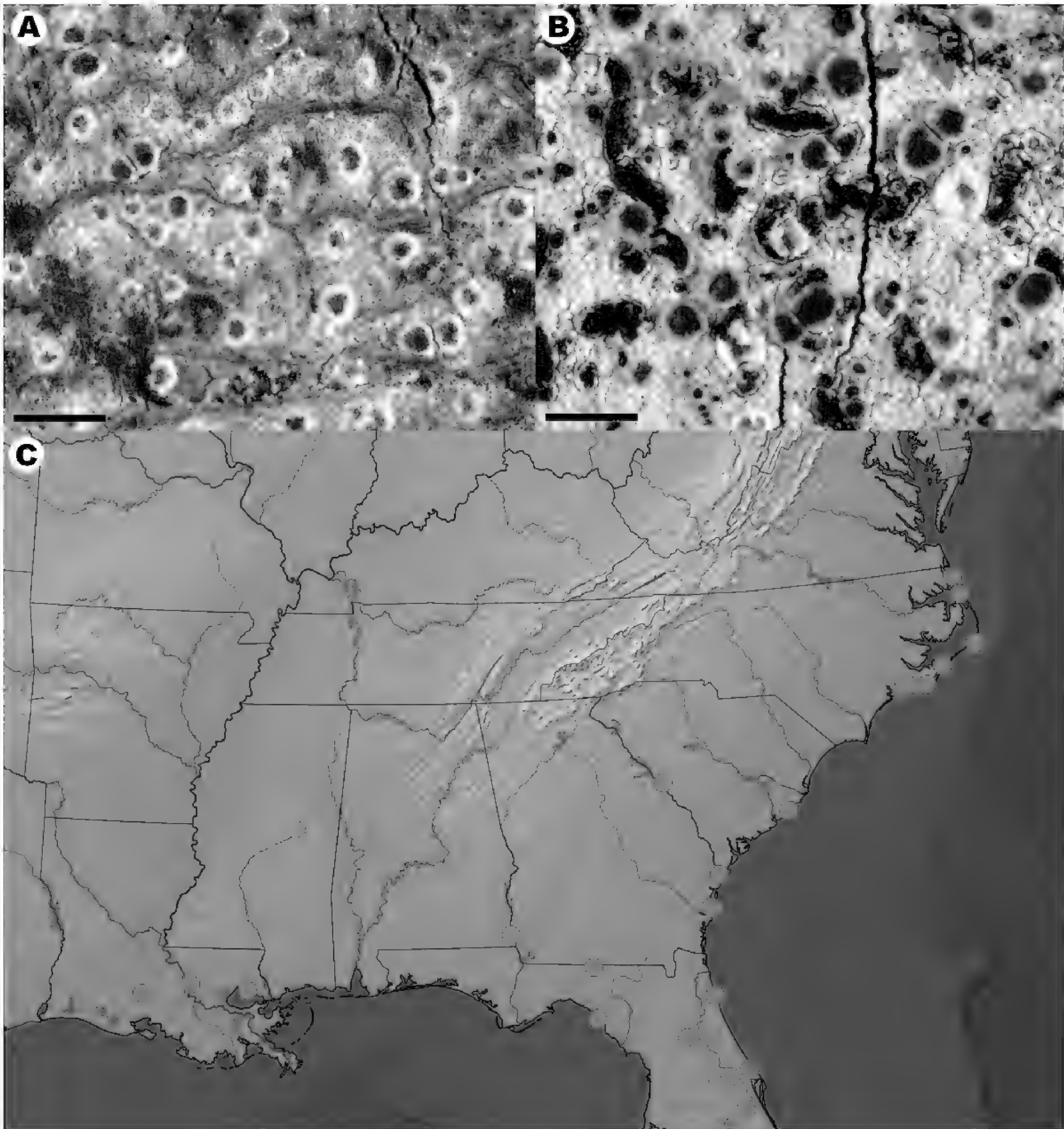
*Schismatomma rappii* (Zahlbr.) R.C. Harris, Evansia 5(1): 5. 1988.

≡ *Haematomma rappii* Zahlbr., Bryologist 33: 31. 1930. **TYPE: U.S.A. FLORIDA.** SEMINOLE CO.: Sanford, xi.1917, on grape, *S. Rapp* 702 (W[n.v.], holotype; FLAS-F29169!, isotype).

Notes. – *Schismatomma rappii* is a morphologically distinctive species of southeastern North America that can be recognized by its small apothecia that have dark brownish discs and ecorticate white margins, somewhat resembling a member of the genus *Byssoloma* (figures 9A and B). During the course of our inventory of the MACP we routinely encountered material with this general morphology, especially in coastal maritime forests. While some of the material conformed to the published accounts of the ascospore size ( $18\text{--}22 \times 3\text{--}3.5 \mu\text{m}$ ) published by Harris (1990, 1995), many specimens had ascospores that were larger in size, measuring  $22\text{--}30 \mu\text{m}$  in length. We were curious if a second taxon with longer ascospores occurred in the MACP, and thus reexamined the material of *S. rappii* available at NY as well as our notes on the type. All of the material filed as *S. rappii* at NY had ascospores comparable in size to those of specimens we thought might represent a new species with longer ascospores (figure 10). Although the ascospores present in the type material fall into the low end of the size range observed in *S. rappii*, they are not discontinuous with those of the rest of the material we examined (figure 10). As such we here report a corrected ascospore size range for *S. rappii* as  $(22.0)\text{--}25.5\text{--}(28.4) \times (3.2)\text{--}3.7\text{--}(4.1) \mu\text{m}$  ( $n=77$ ; average  $\pm$  standard deviation). We also provide color illustrations of the species and a revised distribution (figure 10C).

*Selected specimens examined.* – **U.S.A. FLORIDA.** BREVARD CO.: Merritt Island National Wildlife Refuge, 5.i.1996, on *Celtis*, W.R. Buck 28912 (NY). MADISON CO.: 0.3 mi on dirt road W of CR150, 14.xii.1993, on *Sabal palmetto*, W.R. Buck 24887 (NY). MARION CO.: Florida Greenways along Oklawaha River at Eureka East Boat Ramp, 2.i.1996, on dead petiole of *Sabal palmetto*, W.R. Buck 28800 (NY). SEMINOLE CO.: Little Big Econlockhatchee State Forest, 10.i.1996, on dead petiole of *Sabal palmetto*, W.R. Buck 29214 (NY). ST. JOHNS CO.: Guana Rivers State Park, 24.xii.1995, on dead leaf base of *Sabal palmetto*, W.R. Buck 28609 (NY). TAYLOR CO.: Big Bend Wildlife Management Area, Tide Swamp Unit, 3.xii.1996, on dead leaf base of *Sabal palmetto*, W.R. Buck 31129 (NY). **GEORGIA.** EARLY CO.: Williams Bluff Preserve, ~3 mi W of Cedar Springs, 15.iv.2007, on *Acer*, J.C. Lendemer et al. 9331 (NY). MCINTOSH CO.: Sapelo Island Wildlife Management Area, Cabretta Island, 16.xii.2009,

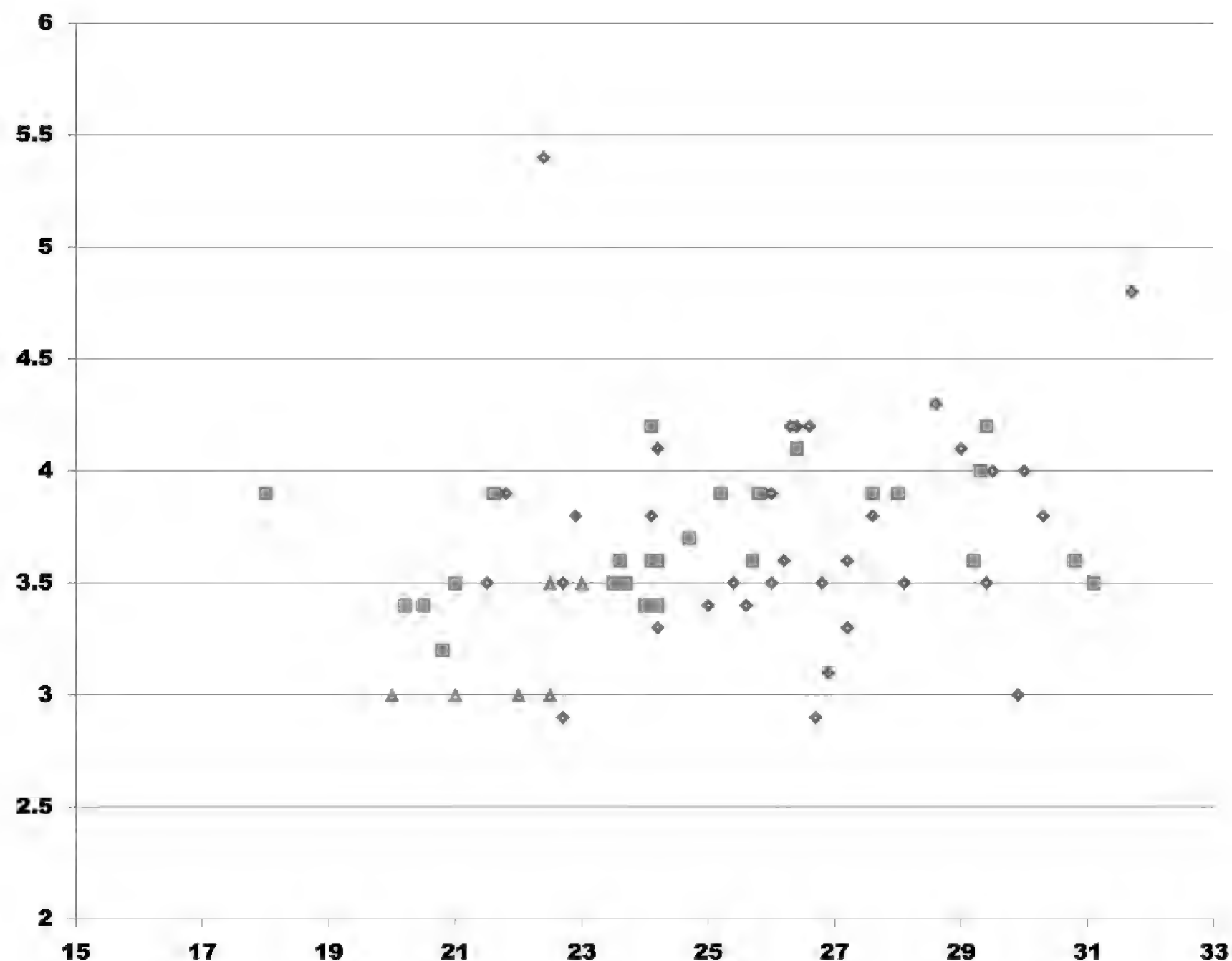




**Figure 9**, morphology and distribution of *Schismatomma rappii*. A, typical thallus and apothecia showing no signs of parasitism (Lendemer 36264). B, thallus and apothecia (denoted by “Sc”) of *S. rappii* appearing to morph out of thallus of *Zwackhia viridis* (denoted by “Op”) (Lendemer 35624). C, known geographic distribution of *S. rappii* based on specimens examined for this study. Scales = 0.5 mm in A and B.

16.xii.2009, on *Juniperus* wood, J.C. Lendemer 20970 (NY). **LOUISIANA.** EAST BATON ROUGE PARISH: Burden Research Plantation, 28.i.1984, on *Platanus*, S.C. Tucker 25859 (NY). LAFAYETTE PARISH: vicinity of Lafayette, 30.i.1932, on bark, B. Neon s.n. (NY). ST. TAMMANY PARISH: Fontainebleau State Park, 2.x.1982, on *Pinus*, S.C. Tucker 25117 (NY). **MARYLAND.** WORCESTER CO.: Nassawango Creek TNC Preserve, Cubler Tract, 13.xi.2012, on *Quercus*, J.C. Lendemer et al. 33682 (NY). **NORTH CAROLINA.** CARTERET CO.: Theodore Roosevelt Natural Area, 7.iii.2013, on *Quercus*, J.C. Lendemer et al. 35558 (NY); Croatan National Forest, Cedar Point Recreation Area, 7.iii.2013, on *Opegrapha* on *Quercus*, J.C. Lendemer et al. 35624 (NY); Cape Lookout National Seashore, Shackleford Banks, 18.iii.2003, on *Quercus*, W.R. Buck 43814 (NY). CURRITUCK CO.: Currituck Banks North Carolina National Estuarine Research Reserve, 14.iv.2012, on *Quercus*, J.C. Lendemer et al. 31115





**Figure 10**, scatter plot of ascospore size in *Schismatomma rappii* (length on the x-axis, width on the y-axis) illustrating the range in sizes observed in the isotype at FLAS (green triangles), the material at NY referred to *S. rappii* previously based on Harris (1995) (red squares), and material at NY initially thought to represent a new species but shown here to belong to a broader concept of *S. rappii* (blue diamonds).

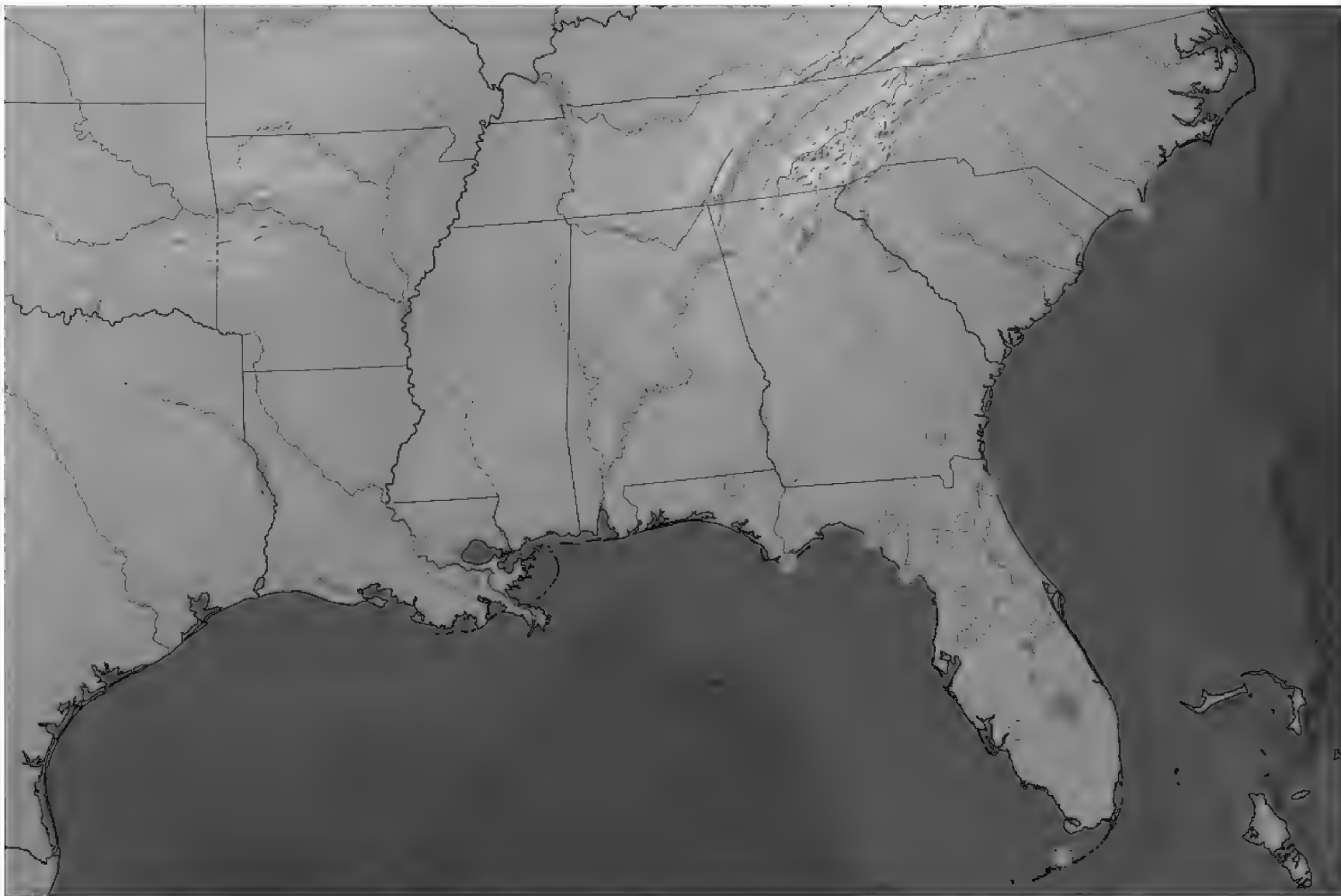
(NY). DARE CO.: Buxton Woods Coastal Reserve, 18.viii.2013, on *Ilex vomitoria*, J.C. Lendemer 36063 (NY); Kitty Hawk Woods Coastal Reserve, 14.iv.2012, on *Quercus*, J.C. Lendemer et al. 31084 (NY); Cape Hatteras National Seashore, Open Ponds Trail, 19.iii.2013, on *Amelanchier*, J.C. Lendemer 36264 (NY). ONSLOW CO.: Hammocks Beach State Park, NE end of Huggins Island, 25.x.2013, on *Magnolia virginiana*, J.C. Lendemer et al. 38642 (NY). **SOUTH CAROLINA.** AIKEN CO.: Savannah River Bluffs Heritage Preserve, 13.iii.2010, on *Ilex opaca*, W.R. Buck 56108 (NY). CHARLESTON CO.: Cape Romain National Wildlife Refuge, Bull Island, 24.vi.1988, on *Quercus*, C.M. Wetmore 61450 (NY).

**VII – TYLOPHORON HIBERNICUM IS THE CORRECT NAME FOR NORTH AMERICAN RECORDS OF *T. PROTRUDENS***

*Tylophoron hibernicum* (D. Hawksw., Coppins & P. James) Ertz, Diederich, Bungartz & Tibell in Ertz, Bungartz, Diederich & Tibell, Lichenologist 43: 354. 2011.

≡ *Blarneya hibernica* D. Hawksw., Coppins & P. James, J. Linn. Soc. Bot. 79: 358. 1980. TYPE: **IRELAND.** COUNTY KERRY: Killarney, Eagles Nest, 1966, on *Cresponea premnea* in dry recess of ancient *Quercus*, P.W. James s.n. (K[n.v.], holotype).

NOTES. – *Tylophoron* is a crustose lichen genus composed of species that produce conical ascomata with a mazaedium of dark brown ascospores with a darker band at the septum and ± pointed ends. The thallus may contain lecanoric acid, 2'-*O*-methylperlatolic acid and lichexanthone. Some of the species



**Figure 11**, known geographic distribution of *Tylophoron hibernicum* in North America based on specimens at NY examined for this study.

produce a sporodochial anamorph with either colorless or brown conidia. Originally thought to belong in the Caliciales (Tibell 1982), it has been found to be an independent evolution of the mazaedial ascomatal type in the Arthoniales (Lumbsch et al. 2009).

When Tibell (1982) treated *Tylophoron protrudens* (Nyl.) Tibell, he circumscribed it to include material both with and without sporodochia although these structures were not discussed at the time. The species was then reported from North America by Thor (1988) who cited a collection from Florida and again did not mention the presence or absence of sporodochia. In treating the genus *Tylophoron* in Florida, Harris (1995) based his concept of *T. protrudens* on authentic material collected by Lindig in Colombia, and on material from the United States with both apothecia and sporodochia that was annotated by Tibell. In a recent monograph of *Tylophoron*, Ertz et al. (2011) asserted in the key that the name *T. protrudens* should be restricted to material without sporodochia while the name *T. hibernicum* should be applied to material with sporodochia. In their treatment, the authors specifically assigned the North American material previously identified as *T. protrudens* to *T. hibernicum*.

As has already been summarized elsewhere (Lendemer et al. 2013), we were skeptical of the treatment of *Tylophoron protrudens* proposed by Ertz et al. (2011) since it differed from our understanding of the species which was based on the examination of authentic material and expert annotations. Recently, while collecting in the Mid-Atlantic Coastal Plain we encountered this taxon at the northern limit of its geographic distribution in North America. In an attempt to decide what name should be applied to the material, we examined digital images of the type of *T. protrudens*. Small white structures resembling sporodochia were present on the specimen. To determine whether these structures were sporodochia or immature apothecia we borrowed the holotype (Lindig 2633, H!). Our examination of the specimen confirmed the circumscription of *T. protrudens* proposed by Ertz et al. (2011) and the interpretation of the white structures on the holotype as immature apothecia rather than sporodochia. Thus the correct name for North American material is *T. hibernicum*.

In southeastern North America *Tylophoron hibernicum* is uncommon but widespread from Florida, northward along the Atlantic Coast to Pender County in central North Carolina (figure 11). Although apothecia are rare in these populations, they are known from material collected in Florida.

Nonetheless, the species can be recognized by its *Trentepohlia* photobiont, white or cream colored sporodochia with fragile irregularly shaped conidia, and the production of lecanoric acid. The most similar species is *T. americanum* Lendemer & R.C. Harris, which occurs in the southern Appalachian Mountains and Piedmont of southeastern North America. It differs most noticeably from *T. protrudens* in the presence of two unknown substances that are C- rather than the lecanoric acid which is C+ red.

*Selected specimens of Tylophoron hibernicum examined.* – **BRAZIL. RIO GRANDE DO SUL:** Mun. Cambará do Sul, Parque Macional de Aparados da Serra, 26.ix.1984, on bark, *W.R. Buck 12311 & D.M. Vital* (NY). **COLOMBIA: DEPT. UNKNOWN:** Tequendama, 1863, on bark, *Lindig 1* (NY). **CUNDINAMARCA:** between San José and Lago Pedro Paulo, 1.viii.1976, *K. Dumont et al. 5456* (NY); Mnpio. Tena, Laguna de Pedro Palo, 23.ix.1984, on *Quercus*, *H. Sipman 5671 & J. Aguirre C.* (NY). **DOMINICA: ST. LUKE & ST. MARKS PARISHES:** Bois Serpé (trail from South Chiltern to Soufrière Bay), 6.xi.1963, on bark, *H.A. Imshaug 32737B & F.H. Imshaug* (NY). **U.S.A. FLORIDA. ALACHUA CO.:** along Sweetwater Branch just N of Boulware Springs Park and NE boundary of Payne's Prairie Preserve, 11.x.1992, on *Magnolia*, *D. Griffin 254* (NY). **CLAY CO.:** Gold Head Branch State Park, 29.xi.1992, on *Nyssa*, *R.C. Harris 29179* (NY). **DUVAL CO.:** Jacksonville Beach, NE corner of intersection of N 20<sup>th</sup> St. and 2<sup>nd</sup> Ave. N., 9.iii.2009, on *Quercus*, *J.C. Lendemer 15891 & W.R. Buck* (NY). **FRANKLIN CO.:** Little St. George Island, Cape St. George, 25-26.v.2002, on *Quercus*, *R. Yahr 4330* (NY). **HOLMES CO.:** E of CR177A, 4 mi NW of SR79 in Bonifay, 10.xii.1993, on *Nyssa*, *W.R. Buck 24730* (NY). **LAFAYETTE CO.:** just W of Fla. Hwy. 51, 5.7 mi S of US27 at Mayo, 29.xi.1994, on *Nyssa*, *R.C. Harris 35560* (NY). **LEVY CO.:** Black Point Swamp, along CR326, 30.xi.1992, on *Fraxinus*, *R.C. Harris 29413* (NY). **OSCEOLA CO.:** Bull Creek Wildlife Management Area, 9.i.1996, on *Sabal*, *W.R. Buck 29178* (NY). **POLK CO.:** Green Swamp Wildlife Management Area, Strand Hammock, 24.iii.1998, on bark, *W.R. Buck 33551* (NY). **SEMINOLE CO.:** Sanford, iii.1928, on *Nyssa*, *S. Rapp 507* (NY). **TAYLOR CO.:** Big Bend Wildlife Management Area, Tide Swamp Unit, 3.xii.1996, on *Magnolia*, *R.C. Harris 39531* (NY). **UNION CO.:** Worthington Springs, along FL121, 4.xii.1994, on *Acer*, *R.C. Harris 35979* (NY). **GEORGIA. WARE CO.:** Laura Walker State Park, 6.xii.2009, on *Nyssa*, *M.F. Hodges s.n.* (NY). **HAWAII:** Mauka of Papaa Bay, Koua, 2.ii.1968, on *Diospyros*, *O. Degener & I. Degener 31462* (NY). **LOUISIANA. EAST BATON ROUGE PARISH:** just SE of jct of Bluebonnet & Stanwick Rds., 3.ii.1982, on bark, *J. Pruski 2314* (NY). **NORTH CAROLINA. BRUNSWICK CO.:** Bald Head Island, Bald Head Island Research Reserve, 21.xi.2013, on large *Quercus virginiana*, *J.C. Lendemer 39995 & J.W. Barton* (NY). **PENDER CO.:** Holly Shelter Game Land, Trumpeter Swamp N of Blossom Creek, 27.x.2013, on large *Nyssa*, *J.C. Lendemer et al. 39072* (NY). **PUERTO RICO:** 3 mi E of Santurce, 3.ii.1899, on tree, *A.A. Heller 447* (NY).

*Selected specimens of Tylophoron protrudens examined.* – **BRAZIL. MATTO GROSSO:** Serra dos Coroados, Buriti, 7.vii.1980, on bark, *K. Kalb s.n.* (NY). **SÃO PAULO:** Mun. Iporanga, Serra Paranapiacaba, Caverna Santana, 29.iv.1984, on bark, *W.R. Buck 12595 & D.M. Vital* (NY). **MINAS GERAIS:** Serra do Espinhaço, Serra do Caraça, 8.vii.1978, on bark, *K. Kalb & G. Plöbst s.n.* (NY). **TRINIDAD AND TOBAGO:** Tobago, Hillsborough Dam on "Mt. St. George – Castara Road", 28.ix.1963, on bark, *H.A. Imshaug et al. 31610* (NY). **VENEZUELA. AMAZONAS. DEPT. RÍO NEGRO:** ridge ca. 1 km SSW of Neblina base camp, 6.iii.1984, on rock, *W.R. Buck 11417* (NY).

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## *Myriospora westbergii* (Acarosporaceae), a new discovery from the Galapagos Islands, Ecuador

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**ABSTRACT.** – *Myriospora westbergii* is described from the Galapagos Islands where it is considered to be endemic. It differs from other species of *Myriospora* by its emergent apothecia with a distinctly elevated thalline margin that increasingly blackens from the inside. The species is most similar in general appearance to *M. hassei*, a lichenicolous lichen parasitic on *Acarospora socialis* which occurs along the coast of California. The new species is clearly distinguished from *M. hassei* by its unusual apothecial anatomy and ontogeny and in having orange pruina occasionally covering the apothecial disc and margin. The epicortex in Acarosporaceae is discussed. *Myriospora westbergii* is the 28<sup>th</sup> species of Acarosporaceae we have reported from South America.

**KEYWORDS.** – Acarosporales, epinecral layer, lichenicolous lichens, parasites.

### INTRODUCTION

The genus *Myriospora* Nägeli ex Uloth represents the former *Acarospora smaragdula* group and is characterized by usually brown or gray areoles or squamules with slender paraphyses (usually 1–2 µm), a tall hymenium (100–200 µm), and a photobiont layer interrupted by hyphal bundles (Arcadia & Knudsen 2012; Knudsen 2005, 2007b; Roux & Navarro-Rosinés 2011; Westberg et al. 2011). The type of the genus is *M. smaragdula* (Wahlenb. ex Ach.) Nägeli ex Uloth. The genus is distributed throughout the northern hemisphere (Knudsen 2007b, 2011; Magnusson 1929; Schiefelbeinet al. in press; Westberg et al. 2011). *Myriospora smaragdula* was recently reported from South America (Knudsen et al. 2012). The genus currently contains nine species, with only *M. smaragdula* being relatively common throughout the range of the genus (Arcadia & Knudsen 2011; Knudsen 2007a; Magnusson 1929; Westberg et al. 2011). The genera *Silobia* M. Westb. & Wedin and *Trimmatothelopsis* Zschacke are considered synonyms of *Myriospora* (Arcadia & Knudsen 2012; Roux & Navarro-Rosinés 2011; Westberg et al. 2011).

This study is part of the lichen inventory of the Galapagos Islands by the Charles Darwin Foundation (Bungartz et al. 2013). Here we describe the new species *Myriospora westbergii* from the Galapagos Islands. It is currently known only from the steep basalt cliffs of Cerro Gavilan, a volcanic crater in the highland of Santiago Island.

### MATERIAL AND METHODS

Herbarium collections of the Galapagos Lichen Inventory are deposited at CDS; other Galapagos specimens from historical collections were also reviewed at several herbaria (B, CAS, COLO FH, H, S), but no material of the new species was found among these collections. For comparison, non-Galapagos material of *Myriospora* from FH, UCR, and hb. Knudsen & Kocourková was studied.

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All specimens were examined with a Zeiss Stemi DV4 dissecting microscope and a Zeiss Imager A1 compound microscope equipped with differential interference contrast. Macro-photographs were taken with a Nikon D800 and/or D300, 62 mm Nikkor Micro Lens and R1C1 macro flash directly in the field, or using a Novoflex macro-table to take images of herbarium specimens; for photographic magnifications higher than 1:1 an extension tube was used. For micro-photographs the compound microscope was equipped with a phototube for the Nikon D300. Photos in the laboratory were taken with ControlMyNikon v5.0Pro. All photographs were databased with the program IDimager 5 using the Darwin Core XML schema to embed collection and identification information as XMP metadata (<http://owl.phy.queensu.ca/~phil/exiftool/TagNames/DarwinCore.html>). Photos were processed with Photoshop CS6.

## TAXONOMIC SECTION

***Myriospora westbergii* K. Knudsen & Bungartz, sp. nov.**

Mycobank #811043.

FIGURES 1A-C, 2A-E.

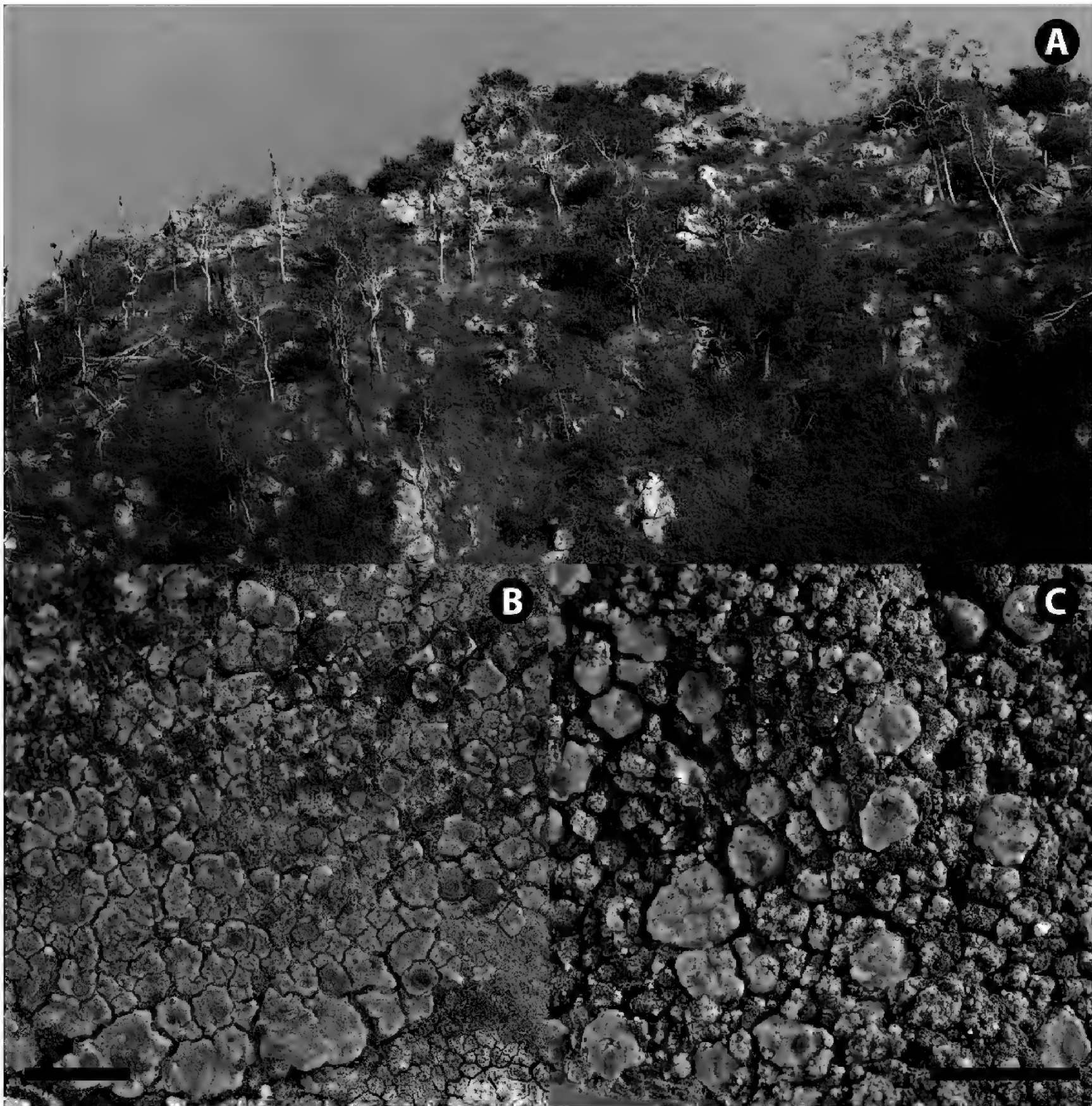
**TYPE: ECUADOR. GALAPAGOS ISLANDS: ISLA SANTIAGO:** summit of Cerro Gavilan, inner N- and NE-exposed crater rim, 12°20'0"S, 90°47'3"W, 840 m, humid zone N- and NE-exposed, steep basalt cliffs of crater rim with ferns (*Pityrogramma calomelanos* var. *calomelanos*, *Polypodium tridens*, *Dryopteris palmata*, *Adiantum concinnum*, *Blechnum polypodioides*), 23.iii.2006, growing on lava rock in crevices, *A. Aptroot* 65667 (CDS 32258!, holotype).

**DIAGNOSIS.** – Similar to *Myriospora hassei*, but distinguished by emergent apothecia that are occasionally covered with coarse orange pruina and, when mature, develop a distinctly elevated thalline margin, which increasingly blackens from the inside.

**ETYMOLOGY.** – The species is named in honor of lichenologist and taxonomist Martin Westberg (b. 1969) of Sweden for his excellent revision of the genus *Myriospora* and continuing work on the Acarosporaceae of Fennoscandia.

**DESCRIPTION.** – *Thallus* of dispersed to closely adjoining, ±circular to irregular areoles, individual areoles broadly attached, ca. (0.3–)0.7–1.0(–2) mm in diameter, ±subsquamulose, indistinctly lobate along the margin; *surface* whitish to pale brown, dull, even to ±irregular, but not conspicuously verrucose, epruinose. *Cortex* differentiated into a ca. 25 µm thick *epicortex* of prosoplectenchymatous conglutinated cells, hyphae irregularly interwoven, not distinctly orientated, not becoming necrotic, subtended by a *eu cortex*, divided into an outer, ca. 5–15 µm thick, prosoplectenchymatous, deep brown-pigmented part, and an inner, ca. 30–45 µm thick, prosoplectenchymatous, hyaline part (all layers devoid of crystals), the outer pigmented part often fading or indistinct in the thallus areoles, but strongly pronounced and best developed in the thalline margin of the apothecia; *photobiont layer* discontinuous, especially towards the center of the areoles interrupted by bundles of hyaline hyphae (ca. 10–20 µm wide), which conspicuously divide this layer into ‘islands’ or ‘packets’ of photobiont cells (ca. 20–60 µm wide); *photobiont cells* trebouxoid, ca. 8–12 µm in diameter; *medulla* of loosely interwoven hyphae, continuous with attachment hyphae below.

*Apothecia* one (or rarely two) per areole, at first immersed, but soon emergent and pseudolecanorine, with a distinctly elevated thalline margin, though not becoming sessile; *disc* at first punctiform to ±urceolate, soon dilating, expanding and becoming concave to barely convex, deep reddish brown, epruinose or rarely covered by a coarse, orange, crystalline pruina (K–, crystals dissolving); *margin* at first inconspicuous, barely elevated, concolorous with the thallus surface, pigmentation pale due to the thick hyaline epicortex, at maturity the epicortex of the prominent margin increasingly abraded, the margin thus darkened to almost blackened. *Thalline exciple* well developed, conical, at the base ca. 250–350 µm wide and filled with clusters of photobiont cells surrounded by densely interwoven hyphae, towards the apex tapering, ca. 50 µm wide, photobiont cells and medullary hyphae disappearing, apical part distinctly stratified into an innermost hyaline part, a central, deep brown layer and the outer, hyaline epicortex;

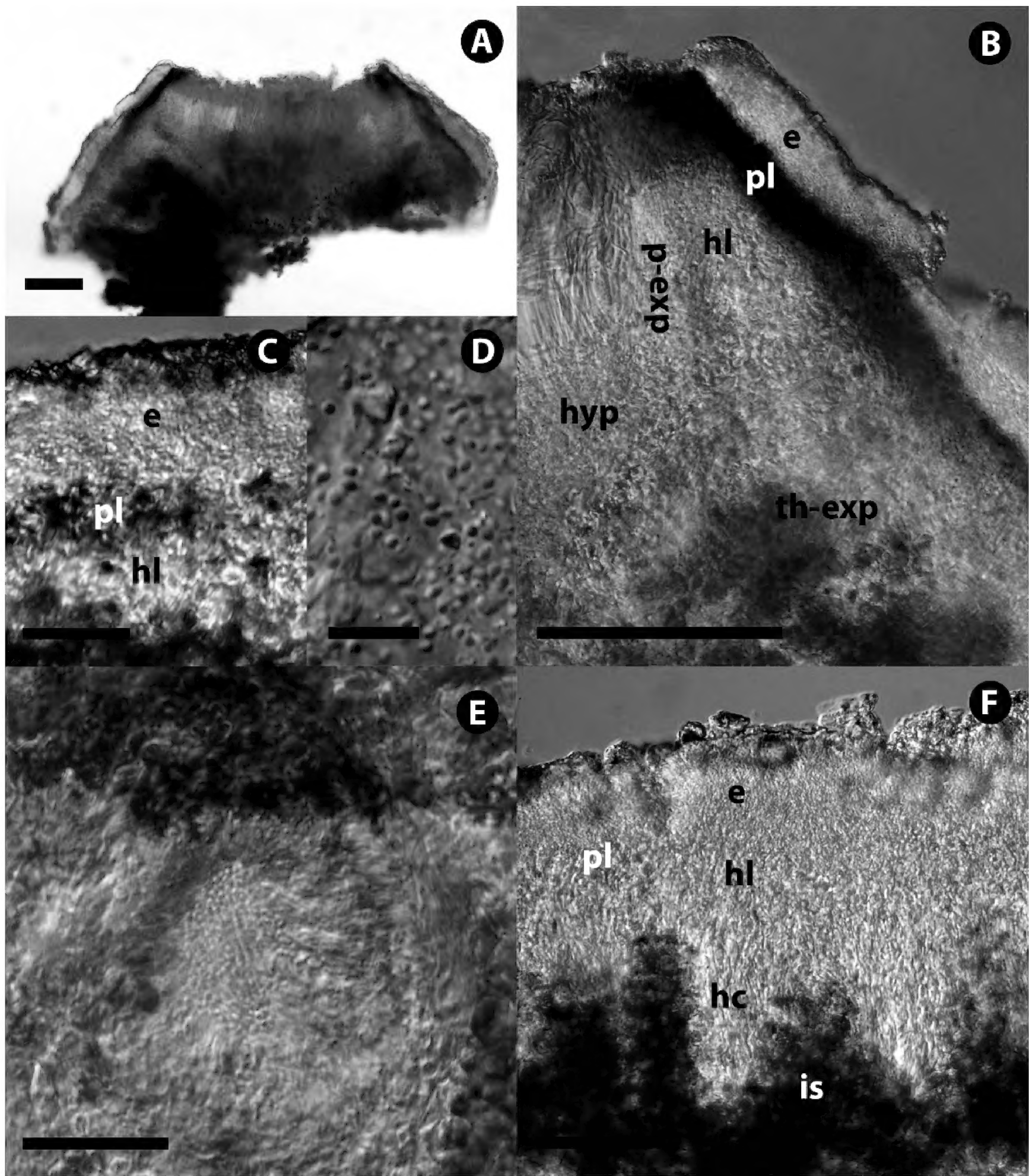


**Figure 1**, type locality (A) and thallus morphology of *Myriospora westbergii* (B, C). A, summit of Cerro Gavilan, Isla Santiago, Galapagos (the photo shows the outer slope of the crater, the specimen was collected on the other side, on the steep N- to NE exposed walls of the inner crater). B, thallus of the holotype (A. Aptroot 65667, scale 15 mm). C, thallus of the paratype (Bungartz 4762, scale 15 mm).

*proper exciple* reduced, barely differentiated from the innermost, hyaline part of the thalline exciple; *epihymenium* ca. 21–30  $\mu\text{m}$  wide, apices of paraphyses in a diffuse pale orange brown pigment; *hymenium* ca. 125–150  $\mu\text{m}$  high, not inspersed, paraphyses at mid-level ca. 1.5  $\mu\text{m}$  wide, apically not significantly wider, not conspicuously swollen. *Asci* clavate, ca. 30  $\times$  8  $\mu\text{m}$ , polysporous (more than 100 spores per ascus); ascospores hyaline, non-septate, oblong (3.5–)4(–4.5)  $\times$  ca. 2  $\mu\text{m}$  (n = 35); *subhymenium* and *hypotheций* not distinctly differentiated, laterally extending into the proper exciple, in the center up to 200  $\mu\text{m}$  thick, sparsely inspersed with tiny oil drops (ca. 1–2  $\mu\text{m}$  in diameter). *Pycnidia* punctiform, urceolate to flask-shaped, wall unpigmented, sometimes adjoining, ostiole colored by a diffuse, brown pigment, conidigenous cells ca. 10  $\times$  1  $\mu\text{m}$ , conidia subglobose, ca. 2  $\times$  1.5  $\mu\text{m}$  (n = 20).

CHEMISTRY. – All spot tests negative, no secondary metabolites detected.





**Figure 2**, anatomy of *Myriospora westbergii*. A, overview of the apothecium (scale 100  $\mu$ m). B, apothecial section showing the hypothecium that laterally transitions into an thin layer of hyphae forming a barely distinct proper exciple, and the well developed conical thalline exciple (th-exp) that is apically differentiated into a thick epicortex (e), pigmented outer layer (pl) and hyaline inner layer (hl) (scale 100  $\mu$ m). C, thallus section close to the margin of a subsquamulose areole showing the differentiation of the hyaline epicortex (e) from the eucortex with an outer,  $\pm$ discontinuous pigmented leayer (pl) and an inner hyaline layer (hl) (scale 20  $\mu$ m). D, subglobose conidia (scale 10  $\mu$ m). E, urceolate pycnidium (scale 50  $\mu$ m). F, thallus section near the center of an areole, where the pigmentation of the eucortex is much reduced or absent (pl) and the photobionts form insular aggregates subdivided by columns of hyphae (hc) (scale 25  $\mu$ m).

DISTRIBUTION AND ECOLOGY. – The only known populations of this species are from the summit area of Cerro Gavillan in the humid zone of Santiago Island in the Galapagos Islands, where the lichen grows among ferns on steep N- to NE-exposed basalt cliffs of the crater rim.

DIFFERENTIATION. – The taxonomy of *Myriospora* is well supported by the phylogeny of Wedin et al. (2009). Often relatively small differences in suites of characters distinguish species (Westberg et al. 2011). This makes many of the species in the genus appear very similar. Until the publication of Westberg et al. (2011) most species that are currently recognized were thought to be variations of *Acarospora smaragdula* (Wahlenb. ex Ach.) A. Massal. (Knudsen 2004, 2007b; Westberg et al. 2011).

Two species, *Myriospora hassei* (Herre) K. Knudsen & L. Arcadia and *M. scabrida* (Hedl. ex H. Magn.) K. Knudsen & L. Arcadia, are known from the coast of southern California (Knudsen 2007b) and look similar to the newly described *M. westbergii* from the Galapagos. *Myriospora scabrida* also forms elevated apothecia, but its apothecial margin is formed by the hyphae of the proper exciple and this margin does not become distinctly blackened around the disk. *Myriospora hassei* differs from *M. westbergii* in having immersed often punctiform apothecia that do not form a conspicuous elevated thalline margin. The two species look similar at early stages of development until the elevated apothecia emerge from the thallus of *M. westbergii*. *Myriospora rhazagida* (Nyl.) K. Knudsen & L. Arcadia, a species that occurs along the Atlantic coasts of North America and Europe, is also similar, but it differs in having immersed apothecia surrounded by a wide black ring around its disc, formed by the expansion of hyphae of the proper exciple. In *M. westbergii* the black pigmentation layer of the margin is clearly part of the cortex and thus hyphae of the thalline margin, not the proper exciple. In the genus, orange to rust-red pruina has only been previously reported on the apothecia of *M. dilatata* (M. Westb. & Wedin) K. Knudsen & L. Arcadia, a montane species that occurs along rivers and lakes in northern Sweden (Westberg et al. 2011).

*Additional specimens examined* (paratypes and topotypes). – **ECUADOR. GALAPAGOS ISLANDS: ISLA SANTIAGO:** summit of Cerro Gavilan, inner N- and NE-exposed crater rim, 0°12'20"S, 90°47'3"W, 840 m, humid zone N- and NE-exposed, steep basalt cliffs of crater rim with ferns (*Pityrogramma calomelanos* var. *calomelanos*, *Polypodium tridens*, *Dryopteris palmata*, *Adiantum concinnum*, *Blechnum polypodioides*), growing on lava rock in crevices, *F. Bungartz* 4762 (CDS 28894), 23.iii.2006 (CDS 56106), *A. Aptroot* 65672 (CDS 56106).

## DISCUSSION

The most conspicuous characters of *Myriospora westbergii* are its apothecial anatomy and the ontogeny of the prominent, distinctly elevated and often dark brown to almost black thalline margin of its apothecia. The dark blackish brown pigmentation develops as a thin, dark rim along the inside of the thalline margin during apothecial ontogeny. At times the increasingly prominent margin thus appears almost subdivided into distinctly separate parts, an outer thalline margin and an inner “parathecial crown”. This observation is, however, misleading. Anatomically, the pigmented hyphae are present already from the beginning of the apothecial ontogeny. They are anatomically *not* part of the proper exciple, but instead correspond to the deeply pigmented part of the eucortex that lies immediately below a thick, hyaline epicortex. In the early ontogeny of apothecia this pigmented layer is entirely covered and thus shielded by the thick, hyaline epicortex, the dark pigmentation thus appearing a dull and pale brown. The dark layer of the eucortex is best seen in mature apothecia, where it is conspicuously exposed. During the emergence of the apothecia the pigmented layer becomes pushed up and out, and the epicortex thus ruptures apically. The dark brown pigmentation then becomes increasingly visible and it eventually dominates the now distinctly elevated thalline margin. During the entire ontogeny, the proper exciple remains reduced to a few, unpigmented hyphae. Elsewhere on the thallus this layer of pigmentation is less prominent and occasionally even fades away.

The epicortex of *Acarosporaceae* was referred to as the “amorphous layer” by Magnusson (1929) and described as an epinecral layer by Westberg et al. (2011). In North and South American species as well as in material that we have examined from Europe, the epicortex is, however, not necrotic. Though occasionally eroded, it forms a protective translucent layer of gelatinized, living hyphae. In *Acarospora rosulata* H. Magn. (reported as *A. bullata* Anzi in Knudsen (2007b)) and in *Myriospora hassei* (reported as *A. hassei* in Knudsen (2007b)), distinct hyphae of the epicortex have been observed to be embedded in a



gelatinous matrix. This is also the case for the newly described *M. westbergii*. The anatomy (including its ultra-structure) and the ecological function of this epicortex in the family merits further study.

The holotype of *Myriospora westbergii* was originally reported from the Galapagos Islands as a poorly developed specimen of *Acarospora trachyticola* (Müll. Arg.) Hue (Knudsen 2012). That taxon is a polymorphic species that infrequently forms a distinctly effigurate thallus, but otherwise has many characters that overlap with those of *M. westbergii*, including an interrupted algal layer. It occurs in the mountains of South America (Knudsen et al. 2012). The discovery and examination of the paratypes led us to reexamine and correct the previous determination. *Acarospora trachyticola*, though having an interrupted algal layer, has not been proven to be a *Myriospora* and especially differs from *M. westbergii* in not developing elevated apothecia with a thalline margin and in lacking reddish orange pruina on the margin and discs of its apothecia.

While examining specimens of *Myriospora hassei* for this study, this species was discovered to be at least facultatively lichenicolous, i.e., a juvenile parasite which eventually develops an independent lichenized thallus. A recent collection from Eel Point on San Clemente Island in the Channel Islands of southern California (Knudsen 16684 & Howe, UCR) revealed *M. hassei* morphing out of the thallus of *A. socialis* H. Magn. (for discussions and illustrations of the phenomenon of “morphing” see Knudsen et al. (2013, 2014). *Myriospora hassei* was initially considered endemic to the California coast (Knudsen 2011) but was later reported from Europe (Roux & Navarro-Rosinés 2011). The distributional range of *M. hassei* closely matches that of *A. socialis* along the coast of California (see distribution map in Knudsen 2011) and it is possible that *M. hassei* is an obligate juvenile parasite on *A. socialis*. The host *A. socialis* is not known from Europe and the European report of *M. hassei* is therefore possibly a misapplied American name.

Utilizing a classical taxonomic approach, *Myriospora westbergii* raises the count of Acarosporaceae now reported from South America to 28 different species (Knudsen 2012). The current morphological species concepts need to be tested with phylogenetic tools sampling a wider range of specimens from South America to develop more robust, consolidated species concepts. The family appears poorly collected throughout much of South America, except for areas studied by Adam Flakus and colleagues (Flakus et al. 2013, Knudsen & Flakus 2009, Knudsen et al. 2012). We expect the diversity of this family to be much higher in South America than is currently known. We look forward to the future South Americans who will make this family their primary focus of research.

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